STOPPING
WATER POLLUTION
AT ITS SOURCE

MISA
Municipal/Industrial Strategy for Abatement

ECONOMIC ASSESSMENT OF WATER POLLUTION ABATEMENT OPTIONS FOR ONTARIO PETROLEUM REFINERIES

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ABSTRACT

The cost-effectiveness and potential economic and financial effects of different levels of water pollution abatement identified for Ontario refineries were assessed in support of effluent limits development for the seven Ontario refineries. Implications of incremental abatement costs, the capacity of firms to pass on these costs as increased product prices and effects on the competitive position and financial performance of the sector as a whole and its constituent firms were assessed. The installed costs of the options examined ranged up to, at most, 0.5 cent/litre of refined petroleum products and would have small to negligible effects on sector and firm finances.

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EXECUTIVE SUMMARY

Industry Trends

Seven petroleum refineries, which are operated by 5 different firms, are subject to the Municipal-Industrial Strategy for Abatement (MISA) Regulations.

Four of the plants are located in and around Sarnia, Ontario, a major petrochemical manufacturing centre; two are situated at the west end of Metropolitan Toronto in Oakville and Mississauga; and the seventh refinery is in the town of Nanticoke on the shore of Lake Erie.

Approximately 7,200 people are employed in these refineries, and the firms that operate them are among the largest corporations in Canada.

Over the past 10 years, demand for petroleum products in Ontario has declined from 92,100 cubic metres per day during 1980 to 79,900 cubic metres per day throughout 1990. Production capacity currently stands at about 95,000 thousand cubic metres per day. Ontario refineries have also exported between 6,000 and 11,000 cubic metres per day over the past decade.

National petroleum product demand has mirrored trends in Ontario. Between 1980 and 1990, declining product demand and rising costs precipitated the closure of 13 refineries throughout Canada, reducing crude oil processing capacity from 705,000 to 310,000 cubic metres per day. It should be noted that only two of these closures occurred in Ontario. Shell, Oakville was closed in 1983 whereas Texaco, Port Credit was closed two years prior to the study period (1980-1990) in 1978.

Effluent Monitoring Program

Ontario refineries completed a year-long effluent monitoring program in 1989. A total of 69 compounds were detected in refinery effluents, of which 15 are classified as "conventional" or non-persistent toxic contaminants. The remaining are persistent, toxic heavy metals or synthetic organic compounds.

Tests for acute toxicity to fish and aquatic invertebrates revealed that effluents from two refineries (Petro-Canada, Oakville and Petro-Canada, Mississauga) were toxic only part of the time. High concentrations of zinc, aluminum, chromium and ionized ammonia in the subject effluents are the probable cause of the toxicity.

Expenses incurred during the Monitoring program amounted to $1.8 million in one-time capital expenditure and $2.2 million in on-going annual outlays.

Cost Analysis of BAT Options

A "Best Available Technology Option" (**BAT Option**) is a set of one or more demonstrated technologies at each plant that could achieve predicted final effluent concentration, pollutant loadings levels, loading reductions or some other specific environmental goal.

Nine abatement technology combinations that could be applied to Ontario refineries were initially identified by a consultant (SAIC Ltd., 1989). Capital and operating costs and potential contaminant removals were estimated for each technology combination. Subsequent assessments narrowed the list of technically feasible and "demonstrated" technology combinations to five:

1. **Chemical Additive Substitution** (CAS). This technology has already been installed in several of the refineries subsequent to the MISA- monitoring program in 1989.

2. Combinations of technologies at each refinery that could achieve flows equal to the U.S. Environmental protection Agency (EPA) Best Practicable Technology (BPT) flow rate as well as the average concentration performance of the 7 Ontario refineries (**Ontario Flow Option**),

3. Combinations of technologies at each refinery that could achieve flow rates comparable to the "best" refinery in Ontario (the Esso, Nanticoke plant) as well as the average concentration performance of the 7 Ontario refineries (**Nanticoke Flow Option**),

4. The Ontario Flow Option plus CAS,

5. The Nanticoke Flow Option plus CAS.

Removal efficiencies were reported for 13 pollutant parameters including 6 "conventional" pollutants:

- oil and grease,
- total suspended solids (TSS),
- dissolved organic carbons (DOC),
- ammonia/ammonium,
- volatile suspended solids (VSS), and
- sulphide

plus 7 "toxics":

- phenolics,
- chromium,
- zinc,
- benzene,
- m- & p-xylene,
- o-xylene and
- toluene.

Many more types of contaminants than the 20 noted above are being discharged by the refineries and the technology options postulated at each plant are expected to reduce many of these additional parameters to some extent.

Estimated capital and operating costs associated with 3 of the technology combinations applied to each of the refineries (except the Esso, Nanticoke plant) and their respective before-tax annualized costs are shown in Table A (page Xi).

The Chemical Additive Substitution technology was estimated to remove 68% (4,205 kg) of the initial loadings (effluent loadings reported during the

MISA monitoring phase) of the persistent toxic contaminants noted above, primarily zinc and chromium.

The Ontario Flow Option can reduce toxic contaminant loadings by an additional 3% (191 kg/yr), while the technologies associated with the Nanticoke Flow Option are expected to remove a further 11% (656 kg) of toxics beyond the level achieved by the Ontario Flow Option.

Chemical Additive Substitution does not reduce any conventional contaminants but the Ontario Flow Option could reduce total conventional contaminants from 6 of the refineries by 29% (390,891 kg/yr). The Nanticoke Flow Option can remove a further 12% (156,608 kg/yr) of total non-toxic contaminant loadings.

Because of uncertainties and the lack of plant-specific data available to the consultant, the actual costs of retrofitting the Nanticoke Flow Option to some Ontario refineries may be higher than the estimates shown in Table B.

Cost effectiveness analyses are based on two measures: the cost per kilogram of pollutants reduced and the ratio of incremental costs per incremental kilogram reduced. Based on these assessments, the Ontario Flow + CAS technology combination is more cost-effective than the Nanticoke Flow Option + CAS with respect to both toxic and conventional contaminants. The associated unit costs of the technology combinations examined are presented in Table B.

Ability to Pass on Cost Increases

Costs associated with the Ontario Flow + CAS Option range between 0.085 ¢ and 0.121 ¢ per litre of petroleum products, depending on refinery capacity utilization rates. If costs were allocated exclusively to motor gasoline, they would amount to between 0.222¢ and 0.317¢ per litre.

Declining product demand, the threat of increased imports from the U.S.A., and a highly competitive market for gasoline and home heating oil in southern Ontario limits the ability of Ontario refiners to raise prices unilaterally in order to offset cost increases.

Financial Assessment of Regulatory Costs on Firms

Despite declining demand for petroleum products over the ten-year period, 1981-1990, Canadian companies that operate refineries in Ontario have been profitable in every year except during the recession of the 1980's. However, declining product demand has combined with the current recession in 1991 to inflict the largest financial losses that the industry has experienced in decades.

These losses and continued weak demand could result in further refining capacity reductions in Ontario, whether or not more stringent environmental requirements are imposed. Cash flow available to fund capital improvements, including various regulatory requirements, has also declined in recent years.

The sum of the estimated abatement

costs plus the monitoring costs that have been incurred were used to determine potential financial impacts of the estimated regulatory costs on the sector and its constituent firms. Historical financial data (10-year average values) were recalculated by adding in the relevant MISA-related costs (and revenues, if any) to determine how each indicator would have changed if the costs were incurred during that period.

Financial impact assessments show that the costs associated with the highest level of abatement (Nanticoke Flow + CAS) would have imposed changes in various key financial indices (e.g. return on capital employed, debt to total assets) of less than 1%. In particular, these expenses would not push financial indicators below the levels recorded during the year in which firms experienced their lowest operating profit.

There is no evidence that costs of these magnitudes alone would precipitate refinery closures.

Effects on the Competitiveness of Ontario's Refineries

At the firm level, two key factors affect competitiveness: the ability to develop and successfully market new or enhanced products or services in order to capture greater market shares or fetch premium prices, and, second, a firm's capacity to discover and implement technological and process changes that reduce production and distribution costs.

At the state/nation level, productivity is the most important determinant of competitiveness. A July 1989 World Competitiveness Report that ranks 22 countries using 292 criteria grouped in 10 categories, highlighted environmental protection regulation only in one category as a determinant of competitiveness. A recent (1991) study by Michael Porter on the competitiveness of Canada's industries, noted that more stringent, proactive environmental regulatory activities that stressed pollution prevention rather than effluent cleanup could enhance productivity and competitiveness.

The following measures and aspects of competitiveness that are pertinent to the petroleum refining sector were analyzed:

a. Capacity utilization rates,
b. Relative refinery cost structures and value added, and
c. Environmental protection requirements in Ontario and other jurisdictions.

Review of these factors yields no evidence that the competitive position of Ontario refineries would be adversely affected if they were to incur potential MISA regulatory costs.

TABLE I
BAT OPTIONS, COST ESTIMATES AND FINAL LOADINGS FOR ONTARIO PETROLEUM REFINERIES

BAT OPTIONS	COST ESTIMATES			FINAL LOADINGS	
	CAPITAL (000'$)	O&M ($000/YR)	BEFORE-TAX ANNUALIZED ($000/YR)	CONVENTIONALS (kg/yr)	TOXICS (kg/yr)
INITIAL LOADINGS				1,348,543	6,173
CHEMICAL ADDITIVE SUBSTITUTION (CAS)	1,000	295	472	1,348,543	1,968
ONTARIO FLOW	57,504	8,617	18,707	957,652	1,777
NANTICOKE FLOW	96,356	13,287	30,252	801,044	1,121

TABLE II
UNIT COST OF TOTAL SUSPENDED SOLIDS PLUS OIL & GREASE AND TOXIC CONTAMINANTS REDUCED BY BAT OPTIONS

BAT OPTION	TOTAL SUSPENDED SOLIDS PLUS OIL & GREASE REDUCED	TOXIC CONTAMINANTS* REDUCED
	$/KG**	
CHEMICAL ADDITIVE SUBSTITUTION (CAS)***	N/A	92
ONTARIO FLOW	83	95,933
NANTICOKE FLOW	102	35,263
ONTARIO FLOW + CAS	83	4,255
NANTICOKE FLOW + CAS	102	5,988

* Phenolics, Chromium, Zinc, Benzene, Toluene, and Xylene.

** Before-tax annualized cost per kilogram reduce.

** CAS removes only Zinc and Chromium.

1 INTRODUCTION

Regulations are now being developed under the MISA program that will specify effluent loading limits for water-borne contaminants being discharged to provincial waterways by industrial dischargers. In the present report, the economic and financial implications of the costs of applying potential water pollution control technologies and programs to Ontario's 7 refineries together with other MISA-related costs are assessed.

Five companies operate seven refineries in Ontario that are subject to the MISA regulations. These refineries produce gasoline, aviation fuels, heating oils, residual fuel oils and petrochemical feedstocks. The companies that operate these Ontario refineries are vertically integrated as they include crude oil production (upstream), refining and marketing (downstream) operations.

Approximately 7,200 people are employed in the 7 refineries and the firms that operate these plants are among the largest corporations in Canada.

Over the past 10 years, demand for petroleum products in Ontario has declined by about 13%; from 92,100 cubic metres per day in 1980 to 79,900 cubic metres per day in 1990, while production capacity currently stands at about 95,000 cubic metres per day. Ontario refineries have also exported between 6,000 and 11,000 cubic metres per day over this period. National petroleum product demand has mirrored the Ontario trend. During this period, 13 refineries were closed in Canada, one of which was in Ontario, reducing Canada's crude oil processing capacity from 705,000 to 310,000 cubic metres per day.

1.1 MISA Program: An Overview

The Municipal-Industrial Strategy for Abatement (MISA) program was announced in a White Paper issued in June 1986, entitled **Municipal-Industrial Strategy for Abatement.** The program is intended to achieve the "virtual elimination of toxic contaminants in municipal and industrial discharges into (Ontario's) waterways." To this end, regulations have been promulgated that have required intensive monitoring of industrial wastewater discharges. Regulations are now being developed which will specify discharge limits for a wide range of contaminants. These limits are to be based on the "Best Available Technology, Economically Achievable" (BATEA) that is specific to each industrial sector.

The economic component of the MISA program is discussed in the report, **Economic Information Needs and Assessments for Developing MISA Monitoring and Abatement Requirements** (Ontario Ministry of the Environment, March 1987)[1].

Estimates of the costs of the MISA monitoring requirements and analyses of their implications for the 7 Ontario petroleum refineries were presented in a report by the Ministry of the Environment (July 1988). This report was the first of a series which detail the costs of the MISA monitoring requirements and their economic implications for plants that discharge effluents directly to surface waters of the province[2].

In the present report, economic implications of the costs of applying potential water pollution control technologies and programs to Ontario's 7 refineries together with other MISA-related costs are assessed.

The analyses follow principles and guidelines set out in the report, Economic Information Needs and Assessments for Development of MISA Monitoring and Abatement

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[1] See also Salamon and Donnan (1988), and Salamon, Donnan, Blyth and Coplan (1990).

[2] Reports on the costs of the MISA monitoring regulatory requirements are also available for the Organic Chemical, Inorganic Chemical, Pulp and Paper, Iron and Steel, Metal and Salt Mining, Industrial Minerals and Metal Casting sectors.

Requirements (Ontario Ministry of the Environment, 1987) and Chapter 6 of the draft "MISA Issues Resolution Document" (June 1990). Specific procedures, methodologies, assumptions and data utilized in these analyses have been developed by the Economic Assessment Subcommittee of the Petroleum Refineries Joint Technical Committee (the EA Subcommittee). Members and contributors to this Subcommittee are listed in **Appendix A**.

1.2 Study Objectives

The primary objectives of the economic analyses are to: 1) evaluate the cost-effectiveness of potential wastewater treatment and abatement program options; 2) show the incremental costs of successively higher levels of contaminant removal (resulting in lower levels of pollutant loadings in wastewaters); and 3) ascertain the potential financial and economic consequences of those abatement program options that are least-cost, together with other MISA-related costs such as monitoring.

The estimates and the results presented in this report do not, at this time, specify or imply what the MISA limits requirements for this sector are or will be. Moreover, rather than concluding whether or not particular firms can "afford" specific levels of control costs, the results presented herein are intended to provide a factual basis for interested parties to form their own conclusions and judgements about the economic effects and trade-offs that are associated with different configurations of water pollution control requirements.

1.3 Petroleum Refining In Ontario

Ontario is one of Canada's major markets for crude oil and refined petroleum products. Five companies operate seven refineries in Ontario that are subject to the MISA regulations. These refineries produce gasoline, aviation fuels, heating oils, residual fuel oils and petrochemical feedstocks. The companies that operate refineries in Ontario are vertically integrated and own and operate facilities in all levels of the oil business from crude oil production (upstream) to refining and marketing (downstream) operations.

Six of the Ontario plants are conventional petroleum product refineries that primarily produce fuels. The Novacor refinery on the St. Clair river south of Sarnia is a petroleum-based producer of petrochemical feedstocks. Four plants are located in and around Sarnia, a major petrochemical manufacturing centre, two are situated at the west end of Metropolitan Toronto in Oakville and Mississauga and seventh refinery is in the town of Nanticoke on the shore of Lake Erie.

Approximately 7,200 people are employed in these 7 refineries and the firms that operate them are among the largest corporations in Canada.

Over the past 10 years, demand for petroleum products in Ontario has declined from 92,100 cubic metres per day in 1980 to 79,900 cubic metres per day in 1990. Over this period, production capacity declined by 23.8 thousand cubic metres per day to the current the 95,000 cubic metres per day. Ontario refinery capacity utilization reported in 1990 ranged from 82% to 90% depending on the source of the data. Ontario refineries have also exported between 6,000 and 11,000 cubic metres per day over this period. National petroleum product demand has mirrored the Ontario trend. During this period, 13 refineries were closed in Canada, one of which was in Ontario, reducing crude oil processing capacity from 705,000 to 310,000 cubic metres per day.

Despite declining demand for petroleum products over the ten-year period, 1981-1990, Canadian companies that operate refineries in Ontario have been profitable except during the recession of 1983 (PMA Reports). However, declining product demand combined with the current recession of 1991 has imposed the largest financial losses the industry has experienced in decades. Cash flow available for capital improvements, including various regulatory requirements, has declined in recent years. Financial losses and continued slow demand may result in further refining capacity reductions in Ontario, whether or not more stringent environmental requirements are imposed.

A recent announcement by Petro Canada Inc. that it would remove the fuel production capacity at its Mississauga plant will reduce total capacity by 6.5 thousand cubic metres per day (MM^{3}PD) or 41 thousand barrels per day (MBPD). Imperial Oil Ltd. also announced its intention to rationalize its operations in Ontario, which would include downsizing its Sarnia refinery. These decisions are seen as consequence of continued slow product demand, particularly for gasoline, poor financial performance in 1991 relative to previous years, and the age and poor cost-competitiveness of some Ontario plants.

Refineries owned by vertically integrated oil companies in Canada are worth over $36 billion in assets while the assets of the entire petroleum industry were valued in excess of $80 billion in 1991.

In 1991, the petroleum industry's annualized rate of return on capital employed dropped to negative 0.5% from 4.8% achieved during the previous year. Net income fell from $3.9 billion to $2.0 billion in 1990 for a loss of $ 1.9 billion in 1991. All refining operations in Ontario experienced significant reductions in their operating and net incomes in 1991 relative to their 1990 financial returns.

2 ANALYTICAL PROCEDURES AND ISSUES

A "Best Available Technology Option" (BAT Option) is a combination of abatement technologies postulated for a given plant that can achieve specific reductions in contaminant concentrations or loadings. In the course of these analyses, it is shown that a number of different technology combinations could be applied to a given plant to achieve successively higher levels of contaminant loadings reduction.

Comparing the average and incremental costs per unit of pollutant removed also reveals which plants can reduce a particular contaminant or group of contaminants more efficiently. The economic and financial impacts of the capital and operating costs associated with the least-cost BAT Options are assessed together with the ability of the regulated firms to pass on the incremental abatement costs to their customers as increased product prices or to their suppliers as lower input costs. The extent to which these incremental costs would affect the small business sector as well as the competitiveness of Ontario refineries are also considered in this report.

2.1 BAT Option Definitions

In order to estimate costs and contaminant reductions, it is necessary to postulate specific technologies and their associated contaminant removal (performance) efficiencies that can be applied to each plant in a sector. The MISA White paper refers to "Best Available Technologies" as one or a combination of specific abatement technologies that may be installed in an existing plant. The draft "MISA Issues Resolution Document" (IRC Document) implicitly defines a "Best Available Technology Option" (**BAT Option**) as a set of one or more demonstrated technologies at each plant that can achieve specific concentration or loading targets, target effluent loading reductions or some other specific environmental goal (IRC Document, pp. 93, 94, 123, 144).

Also, according to the draft IRC Document, at least 4 BAT Options should be identified by the BAT Subcommittees for potential application to each regulated plant in each sector which satisfy the following objectives:

1. Achieve contaminant concentrations or loadings in regulated plants that are attained by the "best" technologies currently in use in North America, Europe or Japan.

2. Achieve contaminant concentrations or loadings in regulated plants that are equal to those prescribed by U.S. EPA regulations for the sector or sub-sector.

3. Achieve contaminant loadings in regulated plants that are comparable to those attained by plant(s) utilizing the "best" technologies currently in use in Ontario in the particular sector or sub-sector.

4. Advance the sector towards the goal of "virtual elimination" of persistent toxic contaminants from effluents of regulated plants.

In addition, BAT Options that would ultimately be considered as a basis for defining contaminant limits should:

1. achieve effluents that are non-lethal to trout and Daphnia magna,
2. employ recycling, reuse and reduction technologies, where possible,
3. minimize inter-media transfers,
4. encourage water conservation.

Additional BAT Options may be defined for each regulated sector. Abatement technologies postulated for Ontario petroleum refineries are defined in Chapter 3. This exercise identified technically feasible possibilities for additional water pollution abatement that are available to Ontario petroleum refineries and the associated costs.

BAT Options constitute specific combinations of abatement technologies postulated for a given plant. An abatement technology can be any device or system that will reduce pollutant concentrations or loadings, including best management practices (BMP), process changes or flow reduction technologies that may be installed in a plant and for which costs may be estimated. Each combination of technologies at a particular plant would result in reductions in certain pollutant loadings from current levels in wastewater streams.

2.2 Economic Assessment Procedures

The economic analyses presented in this report consist of the following steps.

1. The BAT Subcommittee for the Petroleum Sector JTC defines BAT Options and proposed technology combinations at each refinery that will achieve the BAT Option.
2. Derive least-cost abatement cost functions for each refinery with estimates of costs and contaminant removals of each technically feasible technology combination.
3. Assess cost-effectiveness of each BAT Option at each refinery in terms of the cost per unit of pollutant removed and the incremental cost per increment unit of pollutant removed.
4. For each technology combination, determine the distribution of costs and benefits to the regulated firm(s), and contaminant reductions among plants and firms.
5. Analyze the ability of the industry and its constituent firms to pass on regulation-induced costs as increased product prices or reduced input prices in order to offset abatement costs.
6. Assuming that **no** costs can be passed on as higher prices, evaluate the effects of estimated potential regulation-induced costs at specific levels of control or abatement on the financial position of each firm or plant in the sector, to the extent that data are available.
7. Determine whether the competitive position of the regulated Ontario firms and plants (where data are available) might be affected adversely by the potential regulation-induced costs.

8. Where relevant, show the implications for small businesses that may be liable to the regulatory requirements.[3]

9. Determine, where possible, the extent to which the potential expenditures on pollution abatement equipment, installation and operations will stimulate the Ontario Environmental Protection Industry.

9. Address any issues of economic significance peculiar to the sector, as identified by the Joint Technical Committee or its subcommittees, that may be affected by MISA regulatory requirements or associated costs.

Petroleum companies operating in Ontario have registered concern about revealing information that could offend competitive sensitivities and the requirements of the Canada Combines legislation. Consequently, data and estimates that refer to individual refineries are omitted from the body of the report and only aggregate, sector-level abatement cost estimates and their consequences are shown.

2.3 Abatement Cost Functions

In the course of these analyses, it is shown that a number of different technology combinations could be applied to a given plant which would achieve successively higher levels of contaminant reduction (or lower levels of final loadings in the effluent). There may also be more than one combination of technologies that will achieve the same level of contaminant removal at different costs. In this situation, the lowest cost combinations of technologies that can achieve given levels of loading reduction would be selected for derivation of **Abatement Cost Functions**. The range of possible least-cost technology combinations that could achieve specific levels of final pollutant loadings at a given plant can be listed in a table or shown on a graph. These tables and graphs of cost/loadings combinations constitute abatement cost functions for a particular plant.

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[3] A small business is defined as having 100 or less employees and/or gross annual revenues of $1 million or less.

An aggregate, sector-level abatement cost function can also be derived which shows the costs of different levels of contaminant removal for all plants in the sector.

Determination of least-cost technology combinations is a prerequisite to any financial assessment of regulatory costs on the regulated plants, firms or industry. Only least-cost plant-level technology combinations will be analyzed further.

Furthermore, because abatement technologies achieve the simultaneous removal of different mixes of contaminants, the costs of a particular set of technologies applied to a plant cannot be allocated objectively to specific contaminants. An appropriate method of aggregating contaminants that are reduced or removed would have to be specified in order to compare the consequences of one BAT Option with another. Using that aggregation, two measures of cost-effectiveness, the cost per unit of pollutant loading (e.g., $/kg) removed, and the incremental cost per incremental unit of pollutant removed, can be computed. The ratio of the incremental cost per incremental unit of pollutant removed from one technology mix to another is an empirical estimate of the marginal costs of abatement for each plant.

These cost-effectiveness measures can be used to select BAT Options at each plant upon which to conduct further financial and economic assessments. Comparing the average and incremental costs per unit of pollutant removed also shows which plants within a sector, or which sector among those being regulated, can reduce a particular contaminant most efficiently. The results of this particular analysis can be used to help set priorities among contaminants and sectors.

3 POTENTIAL ABATEMENT PROGRAMS, COSTS AND EFFECTIVENESS

Assessment of available technologies resulted in the identification of 5 potential BAT Options to be used in the development of abatement cost functions: Chemical Additive Substitution (CAS), the Ontario Flow Option and Nanticoke Flow Option and CAS in combination with each of the other two options. Uncertainties persist about the Nanticoke Flow Option regarding its costs, and whether it can be retrofitted at all Ontario refineries.

Monitoring data revealed that initial loadings of 6 conventional contaminants found in refinery effluent totalled 1.5 million kg (1,500 metric tonnes) per year. Current loadings of 7 toxic contaminants for which monitoring and removal data are available total 6,172 kg (6.2 tonnes) per year. The maximum abatement level (Nanticoke Flow plus CAS) could reduce these current loadings down to 801 tonnes of conventional contaminants and 1.2 tonnes of toxic contaminants. Installation of the Nanticoke Flow + CAS Option in Ontario refineries could require capital expenditures of at least $96.4 million and operating expenses of $13.3 million per year. On an annualized basis, these expenses amount to $30.3 million before-tax and $18.2 million after-tax.

Ontario refineries would have to spend up to $1 million in capital costs and $295,000 in annual operating expenditures to implement the Chemical Additive Substitution BAT Option. These expenses amount to $472,000 on a before-tax basis and $283,000 on an after-tax basis on an annualized basis.

Capital costs for applying the Ontario BPT Flow Option + CAS BAT Option at each refinery could amount to $57.5 million together with annual operating costs of $8.6 million. The annual before-tax costs to Ontario refineries are estimated at $18.6 million, or $11.3 million after-tax. This is the most cost-effective BAT Option.

3.1 BAT Options for Petroleum Refineries

In this Chapter, the derivation of BAT Options that could be applied to petroleum refineries is described and estimates of the costs of achieving specific levels of contaminant reduction at each refinery are presented for specified technology combinations.

An initial list of 8 potential abatement technology combinations or options that could be applied to Ontario refineries were identified by the BAT Subcommittee through the work of a technical consultant[4]. Subsequent analyses narrowed the list to five potential BAT Options for closer evaluation. Technologies were postulated to be applied at each refinery so that the following objectives would be achieved:

1. Contaminant loadings based on the present US EPA regulation that specifies Best Practical Technology (BPT) flow and concentrations achieved at U. S. refineries[5].
2. Contaminant loadings that would be equal to 85% of the U.S. EPA BPT flow combined with the average contaminant concentrations at Ontario refineries that were recorded during the MISA monitoring period.
3. Loadings equal to the flow and concentration performance of the "Best" refinery in Ontario (the Esso refinery at Nanticoke).
4. Loadings resulting from the addition of Powdered Activated Carbon systems to technologies required to achieve objective # 3.

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[4] **Science Application International Corporation** (SAIC), Paramus, New Jersey in association with Apogee International was hired to investigate BAT Options that can be applied to each Ontario refinery. The Terms of Reference for that study were developed by the BAT Subcommittee of the Petroleum Refining Joint Technical Committee (JTC).

[5] Contaminant loadings are equal to the product of flows and contaminant concentrations over a given time period.

5. The lowest contaminant loadings that can be achieved technically in order to approach "virtual elimination".

Each of the BAT Options considered is deemed to have satisfied the toxicity criterion.

According to the IRC Document, technologies must also be "demonstrated". The IRC Document defines "demonstrated technology" as:

> *"...a technology for which data are available and (those) data can be used to predict, with a reasonable degree of confidence, the reliability of the technology and the performance of the technology with respect to contaminant reductions and effluent variability at any plant in the sector or sub-sector, given the expected variability between plants, and can be successfully retrofitted into existing facilities with a reasonable degree of confidence."*

Combinations of the following technologies were postulated at each refinery to achieve contaminant concentrations and loadings consistent with the specified BAT Options.

1. Chemical Additive Substitution (CAS)

2. Dissolved Air Flotation (DAF)

3. Equalization (EQN)

4. Granular Media Filtration (FLT)

5. Effluent Flow Reduction/Source Reduction (FRN)

6. Polishing Ponds (PND).

7. Process Water Recycling (RCY)

Cost and removal estimates for each of the 5 BAT Options were generated and analyzed, including the "virtual elimination" BAT Option which was estimated to achieve a **zero effluent discharge** level of abatement by means of a combination of vapour compression and distillation technologies.

However, subsequent assessments and reviews by the BAT Subcommittee and the technical consultant, SAIC, concluded that the Vapour Compression/Distillation technology, which was postulated to achieve a 100% removal in contaminants from effluents, did not satisfy the "demonstrated technology" criterion for a MISA "Best Available Technology". Moreover, the Powdered Activated Carbon technology was shown not to be a least-cost option. Consequently, BAT Options that included these technologies were eliminated from further consideration. This left, essentially, only two sets of technology combinations designated as potential BAT Options:

1. Combinations of technologies at each refinery that could achieve loadings equal to U. S. EPA BPT model flow and the average concentration performance of 7 Ontario refineries (Ontario BPT Flow Option).

2. Combinations of technologies at each refinery that could achieve flows equivalent to the "Best" refinery in Ontario; Nanticoke Refinery flow (i.e., 50% of Ontario BPT Flow) and the average concentration performance of 7 Ontario refineries.

The combinations of technologies that could achieve the Ontario BPT Flow BAT Option at each refinery are listed in Appendix B. The combinations of technologies that could achieve further flow and contaminant reductions under the Nanticoke Option include the same types of technologies applied under the Ontario BPT Flow BAT Option with adjusted design specifications **plus** one or two additional technologies for some refineries.

While SAIC stated that further flow reductions could be achieved by some of the refineries, the consultant noted that it had insufficient information to determine, with certainty, whether each of the six refineries, other than Nanticoke, could reduce their effluent flow rates to the extent that is achieved in the Nanticoke refinery. This uncertainty suggests the need for further study of the Nanticoke BAT Option, particularly to identify which refineries can achieve effluent flow levels associated with this BAT Option and at what cost.

It was determined during the 1989 MISA monitoring that anti-corrosion additives containing zinc and chromium were being used in 4 of the 7 refineries. Therefore, reductions in loadings of zinc and chromium could be achieved by substituting other chemicals for those containing these heavy metals. Thus, Chemical Additive Substitution (CAS) constitutes a "pollution prevention" technology which can be implemented by itself as a separate BAT Option or in combination with the technologies that constitute the other potential BAT Options in 4 of the refineries. Some of the refineries report that they implemented substitutions of these chemical additives during and subsequent to the monitoring period.

In addition to Chemical Additive Substitution, Effluent Flow Reduction is considered an in-plant, pollution-prevention technology. The remainder of the technologies are add-on, end-of-pipe devices and systems.

As a result, 5 permutations of BAT Options can be defined for further analysis:

- CAS,
- Ontario BPT Flow,
- Nanticoke Flow,
- Ontario BPT Flow + CAS, and
- Nanticoke Flow + CAS.

The consultant report is silent on whether the flow reductions implied by the Nanticoke Option can be implemented in each of the seven Ontario refineries. It has been suggested that the costs of this BAT Option may be substantially underestimated in any event, as all site specific retrofit costs may not have been included in the cost estimates.

Three key factors determined which abatement technologies where postulated at each refinery:

1. the configuration of existing wastewater treatment systems,

2. the type of products made at each refinery, and

3. contaminant quality of effluents recorded during the monitoring program.

This information is summarized in the following section.

3.2 Products and Installed Abatement Technologies

A summary of end-of-pipe wastewater treatment technologies currently installed at each refinery is shown in Table 3.1. Wastewater treatment technologies employed at each Ontario refinery are extensive and very similar. For example, all refineries, with the exception of the Novacor facility, begin their treatment systems with oil separators. Novacor uses corrugated plate interceptor (CPI) for oil removal. These devices recover oil for reuse and so generate private benefits or a financial payback. Activated Sludge, a biological treatment technology, decomposes and removes dissolved organic compounds. Dissolved Air Flotation (DAF) or Induced Air Floatation (IAF) are used by some plants to further remove waste oil and grease.

TABLE 3.1

MANUFACTURED PRODUCTS AND INSTALLED POLLUTION ABATEMENT TECHNOLOGIES AT ONTARIO REFINERIES

REFINERY	PRODUCTS	INSTALLED ABATEMENT TECHNOLOGIES	RECEIVING WATERS
Esso - Sarnia	Fuel products, packaging, lubricating oil, petrochemical feedstocks.	API separators, activated sludge, sand and anthracite filters, clarifiers	St. Clair River
Esso - Nanticoke	Gasoline, aviation fuel, heating oils, diesel & industrial fuels, propane, butane, sulphur.	API separators, flow equalizer, dissolved air floatation (DAF), activated sludge, clarifiers, recycle ponds, dual media filters**, polishing pond	Lake Erie
Novacor	Petrochemical feedstocks, diesel fuel, furnace fuel, benzene, toluene, xylene (BTX), synthetic natural gas.	Tilted plate interceptor (TPI), flow equalizer, dissolved air floatation, activated sludge, clarifier, granular activated carbon*, holding pond	St. Clair River
Petro-Can. - Mississauga	Liquid petroleum gases, aviation fuel, gasoline, diesel, furnace fuels, residual oil fuels, asphalt, solvents, lubricating oils & grease, sulphur.	API separators, sand filters, flow equalizer, activated sludge, clarifiers	Lake Ontario
Petro-Can. - Oakville	Liquid petroleum gases, aviation fuel, gasoline, diesel and furnace fuels, residual oil fuels, asphalt, sulphur.	API separators, mixed flow equalization, induced air floatation, activated sludge, clarifiers, aerated polishing pond, granular media filters**, holding pond.	Lake Ontario
Shell	Gasoline, diesel, furnace fuels, bunker fuel, BTX, hydrocarbon solvents, sulphur.	API Separators, dissolved air floatation, flow equalizer, activated sludge, clarifier.	Talford Creek, St. Clair River
Suncor	Gasoline, light & heavy fuels, light aromatic products, sulphur.	API separators, vertical tube separators, induced air floatation, flow equalizer, activated sludge, clarifiers, holding pond.	St. Clair River

* Used only for treatment of storm water. ** Sequence considered a tertiary treatment.

Source: SAIC et al. (May 1991), **Status of Wastewater Generation and Treatment in Ontario Petroleum Refineries.**
VHB Research and Consulting Inc. et al. (May 1991), **Water Pollution Abatement Technology and Cost Study**, Toronto: Ontario Ministry of the Environment.

Suspended solids are removed by polishing ponds and various media filters while any remaining free oil is recovered from polishing ponds with baffles and oil skimmers. Flow Equalization is used to prevent wide fluctuations in wastewater flow rates throughout the treatment facilities. The operation of these systems in each refinery achieves relatively low concentrations and loadings of toxic contaminants in final effluents. In addition, plant processes such as sour water strippers and sour water reuse in desalters have been installed by some Ontario refineries.

The types of products manufactured by the each refinery are also listed in Table 3.1 while the quantities of these products produced in Ontario during 1989 are tabulated in Table 3.2. About 50% of total production from Ontario refineries is transportation fuels: gasoline, diesel and aviation fuels. As noted, refineries also recover sulphur as a saleable by-product.

TABLE 3.2

PRODUCTION OF REFINED PETROLEUM PRODUCTS IN ONTARIO

REFINED PRODUCTS	1989 PRODUCTION (000's M^3)	PERCENTAGE OF DAILY PRODUCTION (%)
Motor Gasoline	11,809	36.28
Aviation turbo fuel	1,522	4.67
Diesel fuel	3,508	10.78
Light (furnace and distillate) fuel oil	3,036	9.33
Heavy fuel oil	2,533	7.78
Petro-chemical feedstock	3,385	10.40
Other products	6,759	20.76
Total products	32,552	100.00

Source: Statistics Canada, Catalogue # 45-004, Refined Petroleum Products

3.3 Effluent Quality Input Data and Assumptions

The year-long MISA monitoring program revealed that 53 compounds were detected in refinery effluents (Ontario, Ministry of the Environment, 1990). Fifteen of these contaminants are considered to be "conventional" or non-persistent toxics. Examples of these types of contaminants include total suspended solids, chemical oxygen demanding materials and sulphides. The remaining are dissolved metals or synthetic organic compounds that are toxic or non-biodegradable and persistent.

Because many different contaminants may be reduced by each BAT Option and because costs of BAT Options cannot be allocated to individual contaminants, contaminant loadings reduced must be summed in order to compare the costs and the results of one BAT Option with another and to conduct cost-effectiveness analyses.

However, some of the conventional contaminant parameters reported in the monitoring results are different measures of the same compounds. Adding loadings of these parameters would lead to double counting (eg. total organic carbon (TOC) and oil and grease) and would overstate the actual quantity of pollutants being discharged. However, oil and grease loadings may be added to total suspended solids (TSS) without double counting. Heavy metals and specific organic compounds may be added together without double counting because these compounds are assayed by specific tests.

Simple addition of mass (i.e., kilograms per year) imputes an equal unitary weighting (i.e., x 1) to each contaminant. However, this procedure should not be interpreted as equating the toxicity and damage potential of each contaminant. Two potential contaminant weighting schemes were investigated but were found to be either ambiguous or inconsistent.

1. Weights based on the Ontario Provincial Water Quality Objectives and Guidelines (PWQOs and PWQGs). Application of weights derived from these standards generated ambiguous results.

2. Copper Standard (developed by the U.S. EPA) which provided weighting factors based on human exposure and aquatic life.

Inconsistencies found in these weighting systems underscore the limitations associated with all weighting schemes:

1. Weights are based on value judgements of the analysts or agency who choose and apply the weights and do not necessarily represent the views of other interested parties or the "public" as a whole.

2. Interpretation of weights or weighted measures such as contaminant loadings may be confusing to non-specialists.
3. If unweighted loadings of certain contaminants should not be added together because of double counting, then the weighted masses of these same contaminant loadings should not be summed either.

Therefore, contaminant loadings are not weighted in the present report but the absolute quantities loadings of various parameters are summed for comparative purposes and for computing cost-effectiveness measures.

Pollutant loadings and effluent flows vary directly with the crude oil capacity or throughput and the type of refining processes used (PACE, 1989). Different refining processes also generate different amounts of wastewater. A preliminary assessment of the relationship between actual product output and effluent loadings was completed by the Water Resources Branch but the results revealed no statistically significant correlations among those variables. However, analyses indicated that the correlation between contaminant loadings and crude oil processed was stronger.

Information used in generating cost estimates and potential pollutant reductions or removals include selected technology combination options that make up the BAT Options at each plant, technical compatibilities among feasible technologies, contaminant removal efficiencies for each BAT Option and capital and operating costs for each technology or combination of technologies. Contaminant reductions are determined from contaminant removal efficiency factors or by calculating potential final loadings after abatement technologies are implemented for specific contaminant(s) associated with each technology combination. Cost and contaminant removal estimates are derived primarily from Science Applications International (SAIC et al., May 1991, August 1991) together with VHB Consulting and Research/CH2M Hill (May, 1991), Water Resources Branch and industry sources.

Initial loadings of pollutants being discharged from sector plants were calculated as long-term average (LTA) kilograms per year from data collected during the MISA monitoring program period: December 1988 to November 1989. Potential loading reductions at each refinery resulting from each BAT Option were calculated separately for 13 contaminants as the differences between the initial annual LTA loading and the predicted LTA loadings achieved by the technologies postulated under each BAT Option.

Contaminant removal estimates were reported for 13 pollutant parameters including 6 "conventional pollutants": oil and grease, total suspended solids (TSS), dissolved organic carbons (DOC), ammonia/ammonium, volatile suspended solids (VSS) and sulphide and 7 "toxics": phenolics, chromium, zinc, benzene, m- & p-xylene, o-xylene and toluene. Many other non-target contaminants than these 13 are discharged by the refineries and the technology combinations postulated at each refinery are expected to remove a number of these other parameters.

Results from effluent monitoring and toxicity testing indicate that, out of 42 effluent samples for the sector that were tested with rainbow trout, only one out of six samples from a single refinery failed the toxicity test. Chemical analyses showed that the probable cause of lethality in that refinery's effluent was high concentrations of zinc and ionized ammonia. Similar tests on 42 effluent samples with Daphnia magna showed that process effluent from two refineries (including the refinery with effluent lethal to trout) caused lethality. The probable cause of lethality to Daphnia magna was found to be high concentrations of aluminium, chromium, and zinc. Consequently, it would appear that Chemical Additive Substitution BAT Option alone would reduce lethality to rainbow trout and Daphnia magna.

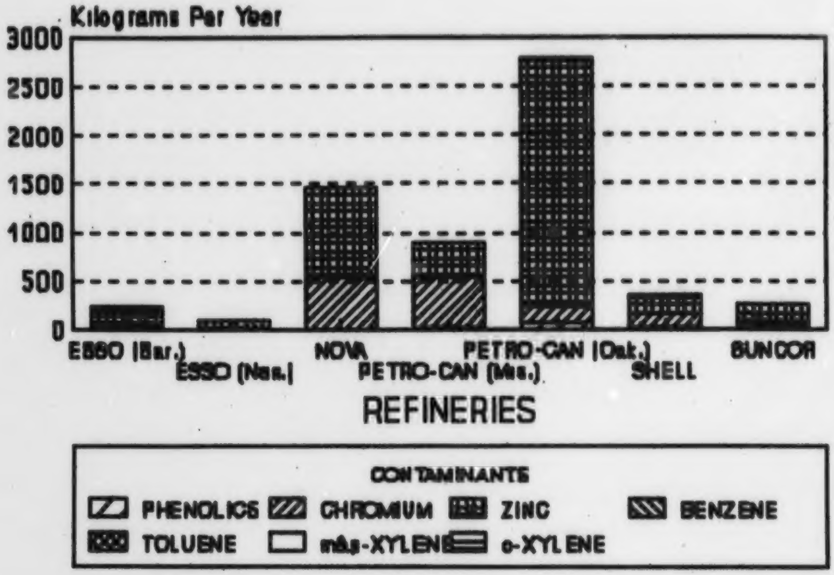
A summary of LTA initial loadings for the 7 persistent toxic contaminants at each refinery is shown in Figure 3.1 while the initial loadings of 6 conventional contaminants are illustrated in Figure 3.2. The data for these Figures are summarized in Appendix B along with annual average process wastewater effluent flow rates (cubic metres per day) and the crude oil processing capacity for each refinery in cubic metres per day (m^3/d). As noted, these 1989 reported initial loadings are discharged from wastewater treatment systems currently installed in each refinery.

Initial loadings of the 6 conventional contaminants total 1.5 million kg (1,500 metric tonnes) per year of which TSS plus Oil & Grease amount to about 624,000 kg (624 tonnes) per year. Initial loadings of the 7 toxic contaminants for which monitoring and removal data are available total 6,172 kg (6.2 tonnes) per year.

Figure 3.1 shows that zinc and chromium loadings from the Nova plant in Sarnia and the Petro Canada refineries at Oakville and Mississauga constitute the bulk of persistent toxic discharges from Ontario refineries. On the other hand, the data in Figure 3.2 indicate that the Shell, Esso, Sarnia and Petro Canada, Mississauga refineries generate the largest quantities of conventional pollutants. These large conventional contaminant

FIGURE 3.1

INITIAL LOADINGS OF PERSISTENT TOXIC CONTAMINANTS FROM ONTARIO REFINERIES



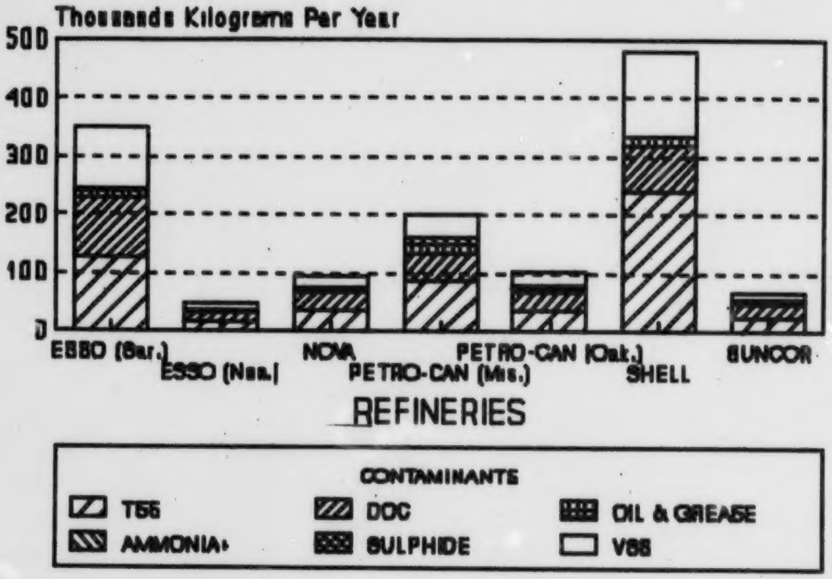
loadings are due, in part, to the large water flows through these refineries relative to the others.

Although as many as 35 permutations and combinations of BAT Options/refineries could be defined for the 7 refineries, only five were analyzed:

1. CAS alone at refineries that use the metal-based anti-corrosion agents.
2 Ontario BPT Flow at all refineries except Esso, Nanticoke
3 Nanticoke Flow at all refineries except Esso, Nanticoke.
4. Ontario BPT Flow + CAS at all refineries except Esso, Nanticoke
5. Nanticoke Flow + CAS at all refineries except Esso, Nanticoke.

FIGURE 3.2

INITIAL LOADINGS OF CONVENTIONAL CONTAMINANTS FROM ONTARIO REFINERIES



Capital and operating costs have been estimated for each technology including flow reduction and sludge disposal, where appropriate. Actual flow rates have also been adjusted to reference flow rates for some refineries (see **Appendix B**). Capital and operating costs of applying technologies defined for each BAT Option are summed for each refinery. Technologies, estimation procedures, assumptions and limitations are described in SAIC et al. (August 1991).

In order to compare and aggregate costs of the various BAT Options at each plant, one-time capital costs must be annualized and added to recurring (annual) operating costs or, future annual operating costs must be discounted and summed. In this report, capital costs are annualized over a period of 10 years at a 12%, before-tax interest rate and then added to before-tax operating costs to show a "typical" total annual expenditure for the abatement program. This "before-tax" cost estimate also represents the cost to society as a whole.

To compute "after-tax" annualized costs that are borne entirely by the regulated firm, total annualized costs are multiplied by a factor, 1-T, where T is the prevailing effective corporate tax rate of 40%[6]. Use of higher interest rates for annualization, where warranted, would increase the annualized cost of the capital component.

3.4 BAT Options and Cost Estimates

Costs and removal estimates for the 3 BAT Option/refinery combinations are summarized in Table 3.3 (ie. CAS, Ontario BPT Flow + CAS, and Nanticoke Flow + CAS). Sector-level aggregate capital, O&M and total annualized costs of the 3 levels of abatement are shown in Table 3.3 along with the total initial and final contaminant loadings for the seven refineries achieved by each BAT Option combination.

SAIC _et al_. (May 1991) suggests that technologies which make up the "Nanticoke" BAT Option, including flow reduction and recirculation, can be installed in some of the Ontario refineries. However, the consultant admits to uncertainty about the technical

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[6] The general annualization formula is:

$$TAC = O\&M \times (1-T) + K \times (i/(1-(i+1)^{-n}) \times (1-T)$$

where:

TAC = Total Annualized Cost
O&M = Operating and Maintenance Costs
T = Income Tax Rate
K = Capital Cost
i = Discount or Interest Rate
n = Life of Abatement Equipment or System

When $T = 0$, TAC represents the "before-tax" cost of the BAT Option which is also the cost to society; when $T > 0$, TAC represents "after-tax" cost which is borne by the polluter.

feasibility of achieving equivalent flow reductions in all Ontario refineries and the possibility exists that such levels of flow reductions cannot be achieved at all in some of the plants. Time and budget have not permitted verification of either of these assertions. Nevertheless, because the Nanticoke BAT Option was one of the final two BAT Options considered by the BAT Subcommittee, it is retained for further assessment and for comparative purposes.

The costs and final loadings associated with CAS only apply to 5 refineries which use the zinc- or chromium-based anti-corrosion additives. Based on the MISA monitoring data, total aggregated initial and final loadings of the 7 persistent toxic contaminants, the 6 conventional pollutants and the sum of TSS plus Oil and Grease are shown in Table 3.3 as well.

Plant-specific details on constituent technologies, costs and initial and final loadings for the 13 contaminants resulting from each BAT Option are listed in Appendix C. Abatement costs vary from one plant to another because of site-specific characteristics including initial flow rates, effluent qualities and existing wastewater treatment facilities.

Total reductions in conventional contaminants achieved by each BAT Option are illustrated in Figure 3.3. Reductions in persistent toxic contaminants resulting from the three BAT Options at each refinery are summarized in Figure 3.4. In both Figures, the distribution of contaminant reductions among each refinery is also shown.

Note that reductions shown in Figures 3.3 and 3.4 are those achieved by CAS combined with the other two BAT Options. Figure 3.3 indicates that CAS achieves no reductions in conventional contaminants. However, the Ontario BPT Flow BAT Option achieves the greatest **incremental** reduction in conventional pollutants while the Nanticoke BAT Option might achieve the largest **total** reduction of conventional contaminants.

TABLE 3.3

TOTAL INITIAL AND FINAL LOADINGS FOR SEVEN ONTARIO REFINERIES, BY BAT OPTION

BAT OPTIONS	COSTS			FINAL LOADINGS FOR CONVENTIONAL POLLUTANTS - Kilograms Per Year							TOTAL
	CAPITAL (000$)	O&M (000$)	ANNUALIZED (000$/YR)	TSS	DOC	OIL & GREASE	AMMONIA +AMMONIUM	SULPHIDE	VSS	TSS + OIL & GREASE	CONVENT-IONALS
INITIAL LOADINGS	→		→	565,642	328,317	57,572	30,180	1,630	365,202	623,214	1,348,543
CHEMICAL ADDITIVE SUBSTITUTION (CAS)	1,000	295	230	565,642	328,317	57,572	30,180	1,630	365,202	623,214	1,348,543
ONTARIO BPT FLOW + CAS	57,504	8,617	11,224	344,989	277,770	53,493	26,973	1,433	252,994	398,482	957,652
NANTICOKE FLOW + CAS	96,356	13,287	18,151	278,903	229,303	48,325	20,279	1,105	223,129	327,228	801,044

BAT OPTIONS	COSTS			FINAL LOADINGS FOR PERSISTENT TOXIC POLLUTANTS - Kilograms Per Year							TOTAL
	CAPITAL (000$)	O&M (000$)	ANNUALIZED (000$/YR)	PHENOLS	CHROMIUM	ZINC	BENZENE	TOLUENE	m-&-p XYLENE	o-XYLENE	TOXICS
INITIAL LOADINGS	→		→	209	1,414	4,416	27	33	40	34	6,173
CHEMICAL ADDITIVE SUBSTITUTION (CAS)	1,000	295	230	209	788	837	27	33	40	34	1,968
ONTARIO BPT FLOW + CAS	57,504	8,617	11,224	162	766	772	13	12	25	27	1,777
NANTICOKE FLOW + CAS	96,356	13,287	18,151	143	405	524	8	7	16	18	1,121

Thus, substitution of organic-based corrosion-inhibiting compounds for the chromium- and zinc-containing additives at 5 of the refineries alone could result in a reduction of 626 kg of chromium and 3,579 kg of zinc per year or a total of 4,205 kg/yr, but no reductions in any conventional contaminants.

Application of technologies to achieve the US EPA BAT Option would remove an additional 95 kg/year of toxics plus about 343,000 kg/year of conventional contaminants, with the notable exception of oil and grease.

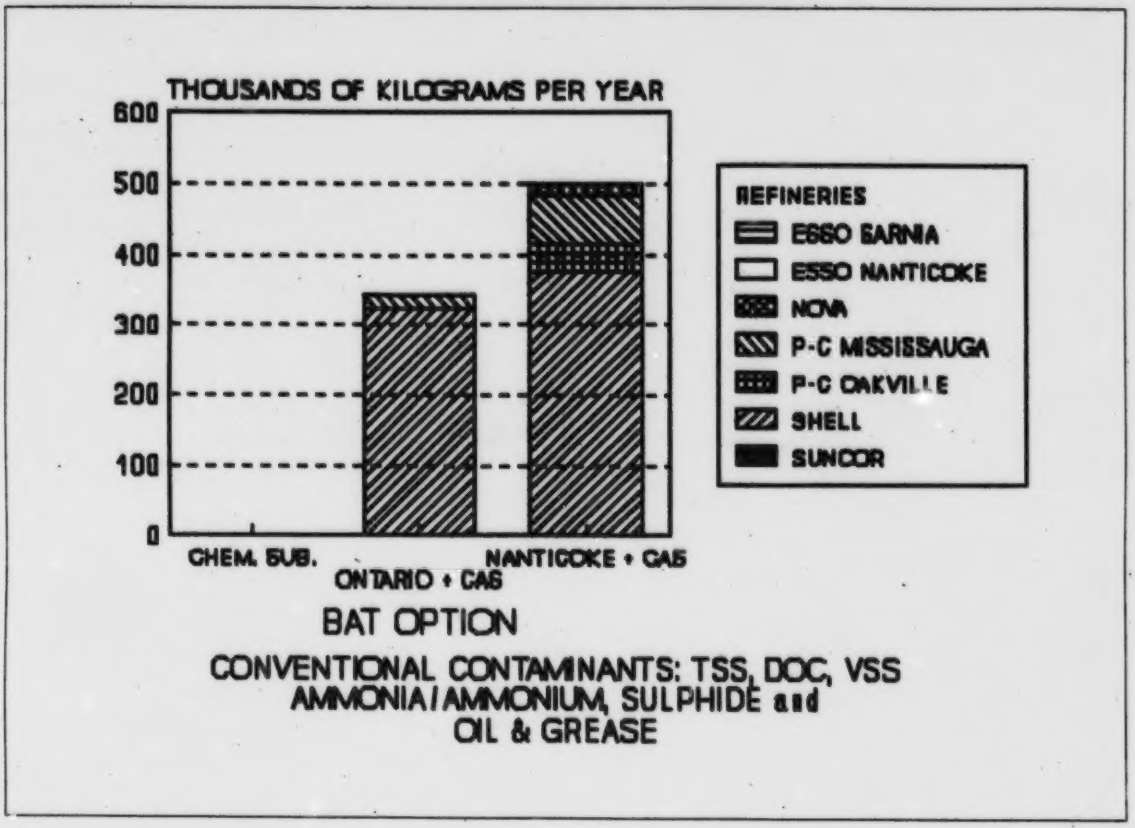
The Nanticoke BAT Option would imply that each of the refineries, except Esso at Nanticoke, install additional control and flow reduction technologies that could remove another 656 kg/yr of persistent toxics and about 150,000 kg/yr (150 tonnes per year) of conventional pollutants. The incremental reductions that could be achieved by the Ontario BPT Flow + CAS or Nanticoke Flow + CAS Options would be the differences in the height of the relevant bars in Figures 3.3 and 3.4.

Figure 3.4 indicates that application of chemical substitution (CAS) alone would account for over 97% of the total reduction in persistent toxics, primarily chromium and zinc, that could be achieved in the Petroleum Refining sector. However, as shown in Figure 3.3, the largest quantities of conventional contaminants would be removed by the Ontario BPT Flow BAT Option from the Shell refinery. No conventional contaminants appear to be removed from the Esso refinery effluents at Sarnia by any identified technologies.

Figure 3.5 displays the capital, operating and annualized costs for each of the three BAT Options. Capital costs for Chemical Additives Substitution amount to $1 million for the 5 refineries that could implement this technology. If each of the 6 refineries installed CAS plus technologies associated with the Nanticoke BAT Option, capital costs are estimated to total $96 million or $18 million per year, after-tax, over 10 years. The

FIGURE 3.3

TOTAL REDUCTIONS IN CONVENTIONAL CONTAMINANTS ACHIEVED BY EACH BAT OPTION COMBINATIONS AT ONTARIO REFINERIES



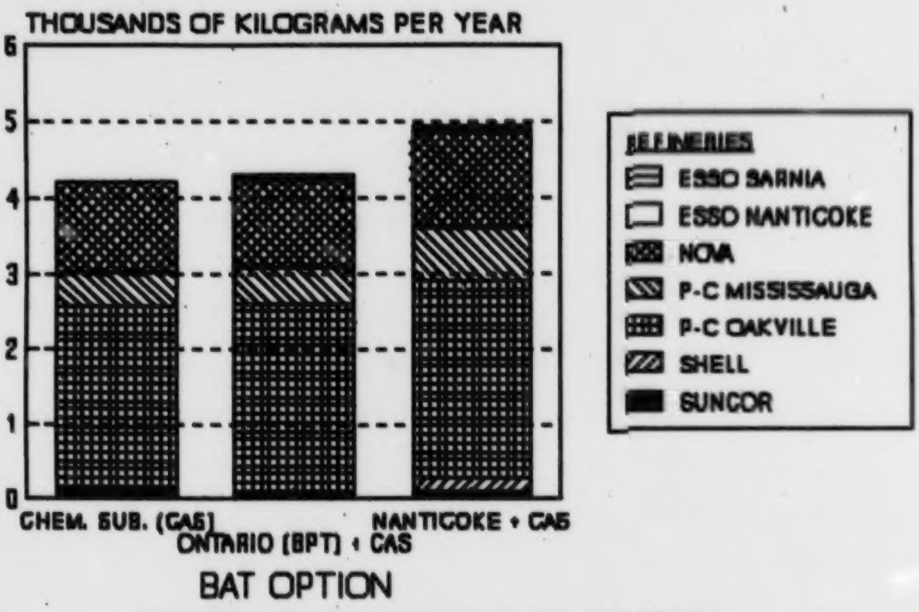
Ontario BPT Flow Option plus CAS would impose about $57 million in capital expenses or $11 million per year on 6 plants over 10 years.

Figure 3.6 shows plots of the annualized after-tax costs of each BAT Option against initial and final loadings of total TSS, DOC and Oil and Grease for the sector. Little reduction in Oil and Grease is achieved by any of the technology combinations posited. Loadings of TSS would be reduced from 565 tonnes per year to about 300 tonnes/yr while DOC loadings would be reduced by 25%, from 328 tonnes to 229 tonnes per year.

Figure 3.7 depicts the total annualized after-tax costs and final loadings for persistent toxics for the sector as a whole. Reductions for the Ontario BPT Flow and Nanticoke Flow BAT Options include persistent toxic contaminant reductions that result from CAS

FIGURE 3.4

TOTAL REDUCTIONS IN PERSISTENT TOXIC CONTAMINANT LOADINGS ACHIEVED BY EACH BAT OPTION IN ONTARIO REFINERIES



TOXICS CONTAMINANTS: ZINC, CHROMIUM, PHENOLICS, BENZENE, TOLUENE and XYLENE.

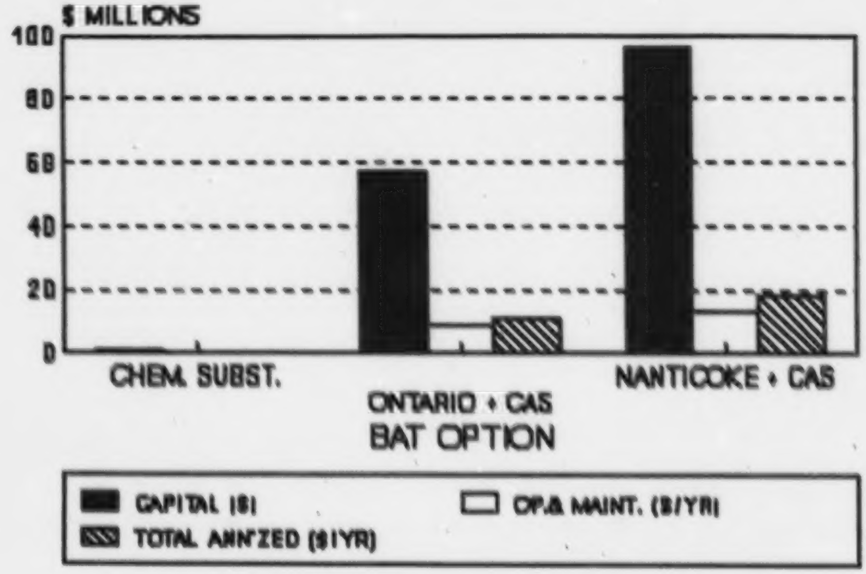
as well. While the incremental reductions of toxics attainable with the Ontario BPT Flow and the Nanticoke Flow Options are relatively small, significant reductions in conventional pollutants are achieved.

The **abatement cost functions** shown in Figures 3.6 and 3.7 indicate that chemical substitution alone can reduce persistent toxics by 4,205 kg/yr (68%) for a minimal cost. Further, the Nanticoke BAT Option plus the CAS technologies can remove 547,499 kg/yr (41%) of the conventional contaminant loadings and 5,052 kg/yr (82%) of the 7 toxic contaminant loadings for which removal information is available.

As per the MISA Issues Resolution Document, certain other environmental expenses may be added to the potential abatement costs estimates prior to analyzing the economic and financial impacts of these costs. These expenses include the costs of the MISA monitoring program and environmental protection activities that may be incurred as the result of a legal instrument (eg. control order, Certificate of Approval) between the beginning of MISA monitoring period (Dec., 1988) and three years after the promulgation of the MISA limits regulation.

FIGURE 3.5

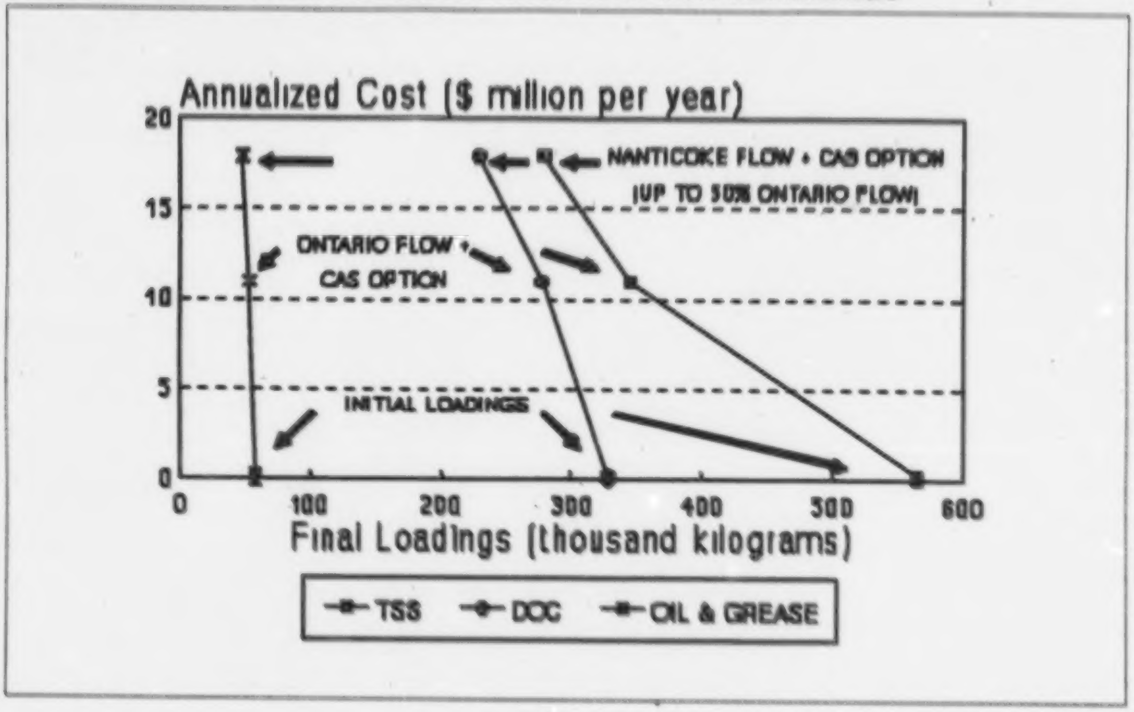
TOTAL BEFORE-TAX CAPITAL, O & M AND AFTER-TAX ANNUALIZED COSTS OF BAT OPTIONS FOR ONTARIO REFINERIES



Initial estimates of the costs of the MISA monitoring requirements program to the 7 petroleum refineries are presented in the report, **Cost Estimates and Implications of the "Effluent Monitoring - General" and "Effluent Monitoring - Petroleum Refining Sector" Regulations for Ontario's Petroleum Refineries** (Ontario Ministry of the Environment, July 1988), together with an assessment of their financial impacts on the constituent firms.

FIGURE 3.6

ABATEMENT COST FUNCTIONS COMPARING TOTAL ANNUALIZED COSTS OF BAT OPTIONS WITH INITIAL AND FINAL LOADINGS OF SELECTED CONVENTIONAL CONTAMINANTS FROM ONTARIO REFINERIES



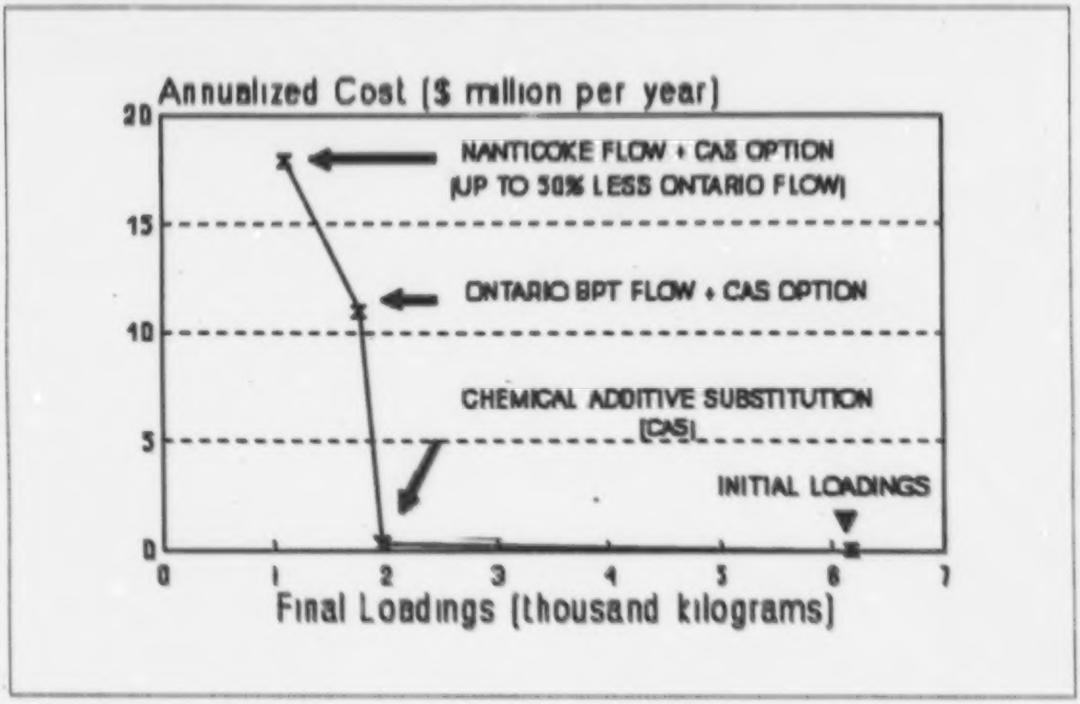
More recently, the actual costs of monitoring have been compiled and are included in the financial impact assessments found in Chapter 5. The actual monitoring costs reported by the 7 refineries are summarized by monitoring function in Table 3.4. No other environmental regulation-induced costs have been supplied by the regulated petroleum companies. The figures in Table 3.4 are added to estimated abatement costs for subsequent analyses and assessments.

3.5 Cost Effectiveness of BAT Options

Each of the 3 BAT Options, including chemical substitution, is presumed to be the least-cost option to achieve the resulting degrees of the contaminant removals, up to the "maximum technically achievable" level of removal as represented by the Nanticoke plus CAS BAT Option.

FIGURE 3.7

ABATEMENT COST FUNCTION COMPARING TOTAL ANNUALIZED COSTS OF BAT OPTIONS WITH INITIAL AND FINAL LOADINGS OF PERSISTENT TOXIC CONTAMINANTS FROM ONTARIO REFINERIES



Thus, technologies that are applied at each refinery to achieve the "Nanticoke + CAS BAT Option," are estimated to achieve the highest degree of total contaminant removal. However, **as noted,** the cost estimates are subject to uncertainty regarding the degree of retrofitting and rebuilding that may be required at some plants.

Cost-effectiveness can be expressed as the cost per unit loading of contaminant reduced. To calculate this measure, the after-tax annualized cost is divided by the mass (kilograms) of contaminants removed per year under each BAT Option. The total kilograms of TSS + Oil & Grease removed per year were used to represent conventional contaminants while the total kilograms of the 7 toxics removed were used to calculate the cost-effectiveness of toxics removal. Since costs could not be allocated to individual contaminant reductions, each of the total reduction values for conventionals and toxics were divided into the total annualized cost to compute the unit cost value.

TABLE 3.4

ACTUAL MONITORING COSTS INCURRED BY ONTARIO REFINERIES TO COMPLY WITH THE MISA MONITORING REGULATION

MONITORING ACTIVITY	CAPITAL COSTS ($'000)		OPERATING COSTS ($'000)		TOTAL COSTS ($'000)	
	Estimate*	Actual+	Estimate*	Actual+	Estimate*	Actual+
Sampling	506.0	399.5	286.3	367.9	792.3	767.4
Flow Meas.	712.0	994.2	58.0	18.2	770.0	1,012.4
Analytical	315.0	339.9	1,066.6	605.3	1,381.6	945.2
Reporting	42.0	102.0	120.3	568.4	162.0	670.6
Consultant Contracts	0.0	0.0	0.0	676.7	0.0	676.7
TOTAL	1,575.0	1,835.6	1,530.9	2,236.5	3,105.9	4,072.3

Source: * Estimates = MOE, July 1988.
+ Actuals = Compiled from responses to Actual MISA-Monitoring Questionnaire, Fiscal Planning and Economic Analysis Branch, 1990 (unpublished).

Based on these computations, which are summarized in Table 3.5, the Ontario BPT Flow Option by itself or in combination with CAS is most cost-effective for conventional contaminants. By itself, the Nanticoke Flow Option is more cost-effective than the Ontario BPT Flow Option for persistent toxics removal. However, combined with CAS, which is the more likely scenario, the Ontario BPT Flow Option is slightly more cost-effective that the Nanticoke Flow + CAS BAT Option combination. If the costs of the Nanticoke Flow + CAS BAT Option are underestimated, the Ontario BPT Flow + CAS Option would have an even greater cost-effectiveness advantage.

Based on the foregoing, the Ontario BPT Flow + CAS BAT Option technology combination in the aggregate appears to be the most cost-effective level of control for both conventional and persistent toxic compounds.

TABLE 3.5

UNIT COST OF OIL AND GREASE, AND TOXIC* CONTAMINANTS REMOVED BY BAT OPTION BASED ON AFTER-TAX ANNUALIZED COSTS

BAT OPTION	Total Suspended Solids plus Oil + Grease Removal	Toxic Contaminants* Removal
	$/year per kilogram removed	$/year per Kilogram Removed
Chemical Additive Substitution (CAS)	N/A**	55
Ontario BPT Flow	50	57,560
Nanticoke Flow	61	21,158
Ontario BPT Flow + CAS	50	2,553
Nanticoke Flow + CAS	61	3,593

Toxic Contaminants* = Phenols, Chromium, Zinc, Benzene, Toluene and Xylene.

N/A** = CAS removes only zinc and chromium.

Consequently, costs associated with two levels of abatement, Nanticoke Flow + CAS and Ontario BPT Flow + CAS plus monitoring costs were used to carry out subsequent financial assessments on the regulated petroleum companies.

4. ABILITY OF ONTARIO PETROLEUM REFINING COMPANIES TO INCREASE PRICES OR REDUCE FACTOR COSTS

The ability of a firm to effect product or input price changes is a function of the structure of the industry, its relevant markets and prevailing trends in product demand. Companies that operate refineries in Ontario are vertically integrated and can maximise profits through transfer pricing among crude oil production and other operational levels. The impact of incremental regulatory costs on a firm's profitability can be mitigated if costs can be passed on as higher product prices to its customers (as is done with sales taxes), or as lower input costs to suppliers.

Estimated abatement and monitoring costs associated with the Ontario Flow + CAS Option range between 0.085 ¢ and 0.121 ¢ per litre of petroleum products, depending on refinery capacity utilization rates. If incremental regulatory costs were allocated exclusively to gasoline, the unit cost would amount to between 0.222 ¢ and 0.317 ¢ per litre.

Product prices are determined by the supplier with the lowest cost of production, called the "marginal supplier." If the marginal supplier is an Ontario refiner, then incremental costs of that supplier may be passed on to consumers as higher product prices.

However, importers are the lowest cost suppliers of petroleum products in Ontario. Buffalo "wholesale" or rack prices for refined petroleum products landed in Toronto form an effective ceiling for Toronto refinery gate prices. Nevertheless, the potential price increases suggested by the incremental per unit costs do not appear large enough to attract substantial additional import volumes.

Declining product demand and a highly competitive Ontario market for refined petroleum products further constrain Ontario refiners' ability to increase product prices to offset incremental regulatory costs. Under current recessionary conditions, price increases of even a cent or less per litre may be difficult to achieve. If the economy recovers, permanent price increases of 0.5 ¢/l would appear to be feasible.

4.1 Vertical Integration

The ability of the Petroleum Refining Sector to pass costs along to consumers or to reduce the prices paid to its suppliers is examined in this Chapter. If regulatory costs can be passed on by petroleum firms to consumers of petroleum products or to suppliers of goods and services to the refining sector, financial impacts on sector firms would be minimized.

The ability of a firm to effect product or input price changes is a function of the structure of the industry and its relevant markets, as well as prevailing trends in product demand and consumption. This relationship is discussed in Part 6, Section 3.3 of the MISA Issues Resolution Document.[7]

Petroleum refineries constitute one of the vertical components of the petroleum industry. Each refinery sells its products to affiliated and independent wholesalers, who in turn supply retail outlets for fuels or manufacturers of chemical products. The major oil companies that own Ontario refineries also own or control most of the retail "gas stations" that operate in Ontario and other provinces.

Major, integrated oil companies therefore have some ability to specify transfer prices of products from refinery to bulk plant and bulk plant to retail outlet and among company divisions so as to maximize profits to the corporation under various tax regimes. Vertical integration in the petroleum industry also helps to ensure that firms have secure markets for their upstream products.

The competitive implications of vertical integration have been debated by economists and in anti-trust fora for many decades. There is no consensus among researchers as to the extent to which vertical integration in the oil industry helps or hinders competition or that vertically integrated companies have undue control over product prices.

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[7] Material found in this Chapter is based, in part, on industry profiles prepared by the Ontario Ministry of the Environment (August, 1988) and Ontario Ministry of Industry, Trade and Development (forthcoming).

4.2 Ability to Change Input (Factor) Prices

Primary inputs to a refinery are crude oil, labour, chemicals and additives, energy and capital investment to keep the refinery running, to upgrade processes and to increase productivity. Waste disposal and pollution control are also important inputs to a refinery operation. Cost increases for one or more of these inputs might be offset by somehow achieving cost reductions for other factor inputs.

There are several ways in which a refinery might, in theory, effect input cost reductions. First, increases in the volume of purchases of a particular input could reduce the average cost to the supplier who could, in turn, offer price discounts. Alternatively, if an oil company is the major, or only, purchaser of a particular product, it may be able to force suppliers to grant discounts, whether or not economies of scale and cost reductions are achieved. Finally, a company might be able to win wage concessions from its employees, especially during periods of severe recession.

In fact, refineries in Ontario are limited in their ability to bring about input cost reductions. The major input to a refinery, crude oil, is actively traded on international markets. Unless there is evidence that a refinery is supplied with crude oil entirely from a firm's own oil wells at costs substantially lower that prevailing market prices, it must be assumed that Ontario refineries pay world market prices as given and these prices are beyond the control of an individual company.

Moreover, many of the workers employed in these plants are protected by collective bargaining agreements. While refineries may lay off non-essential staff to reduce expenses during periods of slack demand, individual petroleum companies have limited ability to reduce wage rates unless there are severe curtailments in economic activity and product demand that would affect all firms or plants employing workers with similar skills.

Another important input, energy, is derived from crude oil whose prices are determined by international market forces over which a firm has no direct control. The cost of capital is determined by the prevailing interest rates and risk premiums over which no single firm has any control. Refineries may be able to exert pressure on suppliers of chemicals and other supplies. However, these inputs constitute a small proportion of total costs.

Consequently, there appears to be little or no opportunity for individual refiners or their parent firms to offset cost increases by obtaining wage or price concessions from employees or suppliers. However, refineries being highly capital intensive and in light ongoing restructuring and rationalization, firms may choose to invest in labour-saving equipment and devices.

4.3 Ability to Raise Product Prices

The ability of a particular firm to pass on increased costs as higher prices depends on the number and relative sizes of competitors in the firm's product market. The fewer the competing firms in a market, the easier it is, in theory, for each firm to increase prices by itself. Firms with monopoly power can generally pass on most of the cost increases they incur as higher product prices. However, monopolies are usually constrained in price setting by regulatory agencies such as the Ontario Energy Board or Public Utilities Commissions.

The oil industry is not a monopoly but the industrial structure that does prevail in Ontario and Canada is characterized as oligopolistic, in which a few very large companies sell to many customers. Oligopolistic firms may find it easier to raise prices than those in competitive markets. Under an oligopolistic market structure, a "price leader" often emerges whose price adjustments are more or less followed by other firms in the market.

Measures of market concentration have been used to judge whether firms in a particular industry or product market are in a position to affect market prices. One such measure is based on the volume of sales, the value of sales or the production capacity of the four or eight largest suppliers in a market as a percentage of total sales volume, value or production capacity. The leading four petroleum companies in Canada accounted for 64 percent of the value of 1985 shipments. The leading eight oil companies accounted for 88.9 percent of the shipments (Ontario Ministry of Industry, Trade and Technology, forthcoming, p 1).

In Ontario, four companies controlled 75 percent of total refinery capacity in 1984 (Ontario Ministry of the Environment, 1988; p 6). This concentration increased when Imperial Oil acquired the Nanticoke refinery from Texaco. A high degree of market concentration implies that, other conditions being equal, the Ontario petroleum industry could have some ability to effect price increases in order to offset increased abatement-costs.

In a competitive market, prices may be increased when input cost increases are incurred by all firms or suppliers. The primary input cost to refineries is crude oil so that increases and decreases in the price of crude are usually passed directly through to rack (wholesale) and retail product prices. However, when crude oil prices increase, Canadian oil companies are constrained by law from immediately raising product prices. Only after they have sold all of their crude inventory that had been purchased at lower prices can they raise prices.

This accounting practice, called "First-In, First-Out" (FIFO), forces Canadian oil companies to wait 30-60 days after a **crude oil price increase** before wholesale product prices can be increased. In contrast, U.S. petroleum suppliers can increase product prices immediately after a crude oil price rise according to an alternative pricing principle called "Last-In, First-Out" (LIFO).

According to Canadian oil industry analysts, when **crude oil prices fall**, Canadian companies are compelled by competitive market forces to reduce product prices in Ontario almost immediately after the price change because of competition from U.S. suppliers (CPPI, 1991 Annual Report).

Consequently, for pricing and internal accounting purposes, Canadian companies are increasingly adopting LIFO inventorying method, since the market sets product prices immediately to reflect changes in input costs. Moving away from FIFO practices for operational reasons seems a logical move if these firms are to remain competitive. However, the FIFO accounting method is compulsory in Canada for income tax reporting purposes.

In general, world crude oil prices have been held above competitive levels since 1973 by actions of the Organization of Oil Exporting Countries (OPEC) oil cartel (Zerker, 1990). Moreover, differences between retail petroleum product prices in Ontario and the U.S. are due, in part, to higher taxes in Canada.

The seven refineries in Ontario produce a variety of products whose markets have somewhat different structural, and competitive characteristics. Six of the refineries concentrate on transportation fuels, diesel and distillate heating oil and lubricants. The Novacor refinery (formerly Petrosar) south of Sarnia primarily produces petrochemical feedstocks, but it does sell some residual fuel oil, distillates and diesel fuels to other major oil companies and independents. Gasoline is by far the dominant product for the industry in terms of total volume and sales revenue.

Ontario refineries and their parent companies compete with one another and with importers in Ontario and other Canadian jurisdictions. Petroleum products market analysts have stated that the Southern Ontario markets, such as Toronto, Windsor and the Niagara Peninsula, are the most competitive and volatile in Canada, primarily because of imports of refined petroleum products. Refined petroleum products can be imported into Canada as well as across provincial borders without tariffs or other restrictions. The frequent swings in retail gasoline pump prices in Southern Ontario are characteristic of keen price competition.

Differences between the Buffalo and Toronto "rack" prices (prices paid by wholesalers or other large customers) for refined petroleum products appear to be a primary impetus for initiating or curtailing imports into Ontario. For example, in August 1991, the rack price for premium unleaded gasoline was CDN 21.71 cents per litre (¢/l) at Buffalo and CDN 24.38 ¢/l in Toronto for a difference of 2.67 ¢/l (Oil Buyers Guide, August 19, 1991). At that time, the cost of transporting one litre of gasoline from Buffalo to Toronto ranged between CDN 1.4 and 1.7 ¢, giving imports a price advantage of 1.0 ¢/l to 1.3 ¢/l. If the Buffalo/Toronto price difference falls below 1.4 ¢/l, importers will lose their price advantage and would likely reduce shipments into the Ontario market.

Buffalo rack prices of refined petroleum products landed in Toronto form an effective ceiling for Toronto refinery gate prices. On average, the observed sum of Toronto rack and transaction prices seldom exceeds Buffalo rack prices plus transport costs from Buffalo (McFetridge, 1989). It appears, therefore, that imports from Buffalo have the ability to constrain Ontario refiners from raising refinery gate prices of gasoline and other products.

Interprovincial transfers of refined petroleum products into Ontario, which amount to approximately 18,000 barrels/day (2,860 m^3/d) in 1990, constitute another source of competition for Ontario refiners. It should be noted that portion of this volume is brought in by firms that operate refineries in Ontario.

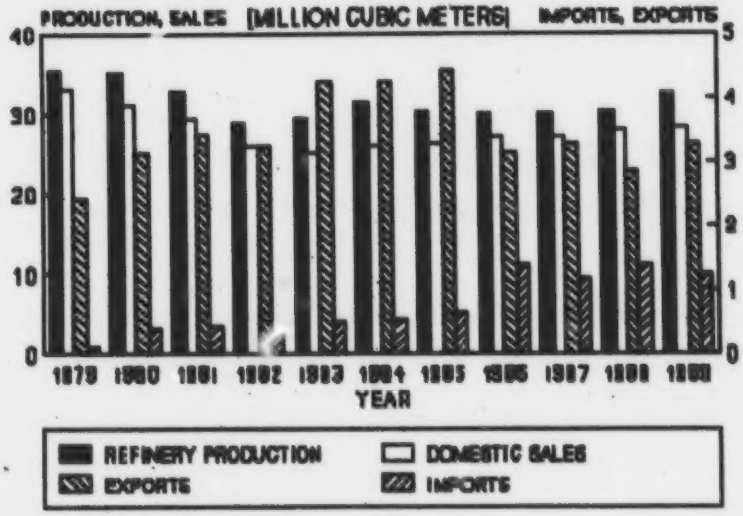
When Ontario pump prices (net of taxes and retail margins) increase, imports by independents and other competitors in the U.S. and elsewhere are attracted to this market. In recent years, retail gasoline pump prices have fluctuated by as much as 10 cents per litre over a period of one week in the Toronto regional market. These shifts have been due, in part, to competitive pressures from imports and transfers of product from other provinces.

Data in Figure 4.1 show that exports of all refined petroleum products from Ontario refineries have exceeded imports between 1979 and 1989. Exports of gasoline shown in Figure 4.2 have also exceeded imports in each year between 1979 and 1989, except 1988. Because of transport cost differentials, products may be exported from one region of the province while being imported into another region by the same company. The product mix at each refinery can also be changed to accommodate seasonal demand patterns and price differentials. A product may be imported during one season and exported during the remainder of the year because of price fluctuations.

Figure 4.2 shows that, even though Ontario has exported more gasoline than it has imported, more gasoline has been sold each year than has been produced in the province. This shortfall between domestic gasoline consumption and domestic production is supplied by imports and inter-provincial transfers.

FIGURE 4.1

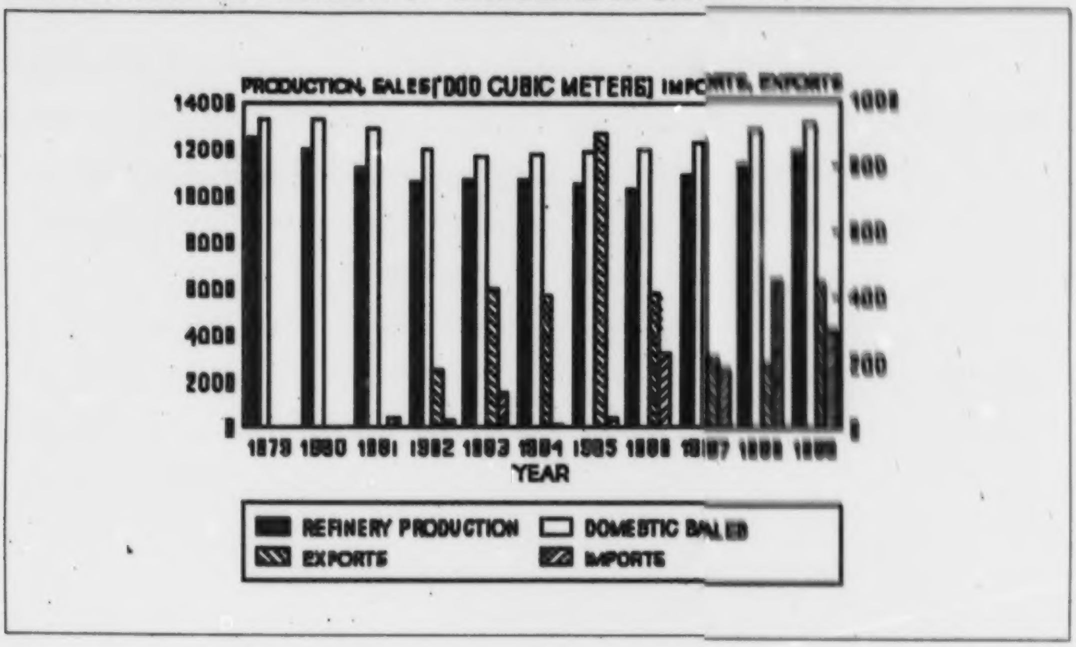
SUPPLY AND DISPOSITION OF PETROLEUM PRODUCTS IN ONTARIO, 1979-1989



Ontario refineries face competition from imports and transfers of petroleum products, or from the threat that imports would become available if Ontario prices were high enough. Petroleum product importers must have storage and distribution facilities called "bulk plants" where large quantities of product arrive by marine cargo or train and smaller

FIGURE 4.2

SUPPLY AND DISPOSITION OF GASOLINE IN ONTARIO, 1979-1989



quantities are sent out by truck to customers[8]. The majority of Ontario's independent bulk plants or terminal operators have their facilities within trucking distance from Buffalo. Ontario refiners also operate bulk plants.

As shown in Table 4.1, independent firms operate about 270 wholesale bulk plants in competition with major firms. Oil companies that own the refineries in Ontario operate 277 bulk plants, including all of the largest capacity (> 250 million l/yr) bulk plants. Other major oil companies, wholesalers and retailers, that do not operate refineries in Ontario (e.g., Ultramar Canada Inc, United CO-OP) own and operate an additional 70 bulk plants in the province. Independent marketers have the capacity to supply up to 20% of Ontario's domestic gasoline consumption from imported product (McFetridge, 1989).

Independent wholesalers and retailers obtain products from major oil company refineries but, as shown in Table 4.2, the majority of imports of gasoline and light fuel oils is brought in by independent terminal operators. Some of the larger independent retailers obtain imported products directly from U.S. suppliers. Oil company representatives argue that independent bulk plants and retailers who have access to imports exercise a strong competitive restraint on price increases in Southern Ontario. The fact that about 75

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[8] Facilities for holding and storing gasoline and other petroleum products before shipment, or sale to wholesalers and retailer.

TABLE 4.1

TYPES AND NUMBERS OF ACTIVE PETROLEUM PRODUCTS BULK STORAGE AND DISTRIBUTION PLANTS IN ONTARIO

CLASSIFICATION BY	OWNER FIRMS	FACILITY SIZE (MILLION LITRES/YR)			NUMBER OF PLANTS	PERCENTAGE
		TERMINAL (>250)	BULK PLANTS (30 - 250)	BULK PLANTS (< 30)		
OWNER/ OPERATION	IMPERIAL OIL	7	8	86	101	18.4
	PETRO-CAN	3	4	83	90	16.4
	SHELL	1	10	64	75	13.7
	SUNOCO	3	2	6	11	2.0
	OTHERS*	1	1	68	70	12.8
	SUB-TOTAL	15	25	307	347	63.3
	INDEPENDENTS	0	N/A	N/A	201	36.7
	TOTAL	15	N/A	N/A	548	100.0
REGION	NORTH A	0	8	80	88	16.0
	NORTH B	0	N/A	N/A	23	4.2
	NORTH C	0	N/A	N/A	111	20.3
	CENTRAL A	6	16	227	249	45.5
	CENTRAL B	0	N/A	N/A	157	28.6
	CENTRAL C	6	N/A	N/A	406	74.1
	T-H-C A	9	1	0	10	1.8
	T-H-C B	0	N/A	N/A	21	3.8
	T-H-C C	9	N/A	N/A	31	5.7
	TOTAL	15	N/A	N/A	548	100.0

NOTES:
NORTH = Northern Ontario
CENTRAL= Central Ontario
T-H-C = Toronto-Hamilton Corridor
N/A = breakdown not provided

* Ultramar Canada Inc., United CO-OP in Ontario
A = Major Oil Companies
B = Independents
C = Total

percent of all imported gasoline is purchased by independent, private brand marketers supports this contention. Furthermore, sales by independents comprise 20 to 25 percent of the retail market for gasoline in Ontario.

To the extent that ample quantities of refined petroleum products are available for import from U.S. suppliers, it will be more difficult for producers to make price increases in Ontario stick. Thus, the ability of Ontario refineries to set prices in Ontario markets, or anywhere else for that matter, may be limited in spite of the net export position of these refineries.

TABLE 4.2

IMPORTATION OF REFINED PETROLEUM PRODUCTS INTO ONTARIO

PRODUCT TYPE BY YEAR	THOUSANDS OF CUBIC METRES (M^3) PER YEAR				IMPORTS AS A % OF DOMESTIC PRODUCTION
	DOMESTIC PRODUCTION[1]	IMPORTS[2]			
		REFINERY IMPORTS	INDEPENDENT MARKETERS	TOTAL IMPORTS	
GASOLINE					
1987	11,451	108	186	294	2.6
1988	12,701	81	326	407	3.2
1989	12,429	10	281	291	2.3
1990	11,643	n/a	n/a	222	1.9
DIESEL OIL					
1987	4,047	n/a	39	39	1.0*
1988	4,466	n/a	62	62	1.4
1989	4,141	n/a	39	39	0.9
1990	3,997	n/a	n/a	60	1.5
DISTILLATE FUEL OIL					
1987	2,641	26	90	116	4.5
1988	2,009	60	133	193	9.7
1989	2,984	1	32	33	1.1
1990	2,897	n/a	n/a	116	4.00

1. Statistics Canada, Cat. # 45 - 004
2. Statistics Canada, International Trade Division
* Imports by independent marketers only.

Motor gasoline accounts for approximately 36 percent of refined petroleum products production in Ontario. Between 1987 and 1990, gasoline imports account for less than four percent of gasoline sales in Ontario (Table 4.2). As is apparent from Figures 4.1 and 4.2 and Table 4.2, the amounts of gasoline and diesel fuels imported by independents and refiners has not exceeded 10% of Ontario's production of those petroleum products. As noted, independent importers have the bulk plant and transport capacity to import up to 20% of Ontario's total gasoline consumption (McFetridge, 1989). These facts supports industry assertion that refined petroleum product price increases (net of taxes) by Ontario refiners would lead to rapid product imports, particularly with respect to gasoline. Imports or the threat of imports, therefore, could frustrate any attempt by refiners to increase product prices.

In addition to imports, product demand trends can also affect the ability of refineries to dictate product prices unilaterally (Fesharacki and Isaak, 1985). Periods of rising product demand lead to high rates of capacity utilization and a greater ability for firms to pass on higher refinery production costs as higher prices to retailers and consumers.

Conversely, low rates of capacity utilization is usually associated with declining demand. Over the last ten years, capacity at Ontario refineries has been curtailed including the closure of the Shell, Oakville plant in 1983. In Canada as a whole, declining product demand has resulted in a 56% drop in refining capacity from 705 MM^{3}PD in 1980 to approximately 310 MM^{3}PD in 1990 and 13 refinery closures. The most recent being the Petro-Canada refinery in Port Moody, British Columbia. Ontario's current 95 MM3PD production capacity also reflects the low demand for petroleum products in the province. Consumption of petroleum products in Ontario fell 13% from 92.1 MM^{3}PD in 1980 to 79.9 MM^{3}PD in 1990. In 1990, Ontario's consumption represented 33.4% of the Canadian demand, a slight increase over the 1980 figure when the province accounted for 31.5%.

However, because refineries are capital intensive, the marginal cost of producing extra product is very low. Producers thus have an incentive to keep producing as much product as possible and sell at lower prices in order to move the extra products, even when demand is falling. Also, when refineries produce more products than they can store, they have an incentive to move products by selling at a discount from prevailing list prices.

According to some industry observers, prices are determined by the supplier with the lowest costs of production, called the "marginal supplier". If the marginal supplier is an Ontario refinery, then incremental regulatory costs could be passed on to consumers as higher product prices by this supplier. Other, higher cost suppliers will welcome higher prices.

However, if the marginal supplier to Ontario is an importer rather than a refiner, the importer would not be subject to the MISA regulatory requirements on refineries and would have no incentive to raise their prices. Consequently, refiners' capacity to increase prices will be constrained because importers will continue to undercut them.

A third factor that limited unrestrained price increases by producers was the Petroleum Monitoring Agency (PMA) although that was not it expressed function. Crude oil prices under the National Energy Program of the seventies and early eighties were regulated by the federal government. Crude oil price controls were lifted in 1985 but the Petroleum Monitoring Agency continues to track, and report on, changes in the prices of crude oil and petroleum products as well as gross margins and other sector-specific indicators.

The Petroleum Monitoring Agency, through its semi-annual and annual reviews on the sector's performance, has provided an indirect constraint to price increases for petroleum products. Following the 1992 federal budget PMA was eliminated but its functions and duties were integrated into Energy, Mines and Resources Canada and are currently performed by the Petroleum Monitoring Division.

Finally the price elasticity of demand can influence price setting for particular products. Price elasticity refers to the expected percent change in the quantity of a product that is purchased when prices are increased or decreased. Over observed price ranges, gasoline and distillate home heating oil are generally price inelastic in the short run (over a period less than a year) which means that the percent decrease (increase) in the consumption of these products will be less than the percent increase (decrease) in the product price (Hycarb Engineering, 1983). Where products are price inelastic, producers may be able to effect small price increases over the short run with only as small corresponding reduction in product consumption. Over time periods of two or more years, measured price elasticities are generally more price elastic. Reductions (increases) in consumptions may be more pronounced and measurable as a consequence of price increases (reductions).

However, it is uncertain whether cost increases that would be required to recoup potential MISA-related regulatory costs would be high enough to attract large increases in imports. Toronto rack prices for gasoline usually do not exhibit immediate adjustment to changes to Buffalo rack prices (McFetridge, 1989). There appears to be a four to six-week lag for any supply adjustments to take place after a price change. This adjustment lag implies that there is a short-term supply inelasticity.

This import supply adjustment lag is a consequence of physical factors such as:

- the availability of, and access to, additional gasoline for export from Buffalo and other border terminal points;
- the availability of pipeline space, tanker trucks, and ships for transportation;
- the capacity of ports of entry and other border points to handle increased product volumes.

Over periods beyond 12 weeks, supply elasticity of imports appears to be infinitely elastic to price increases. Therefore, imports or the threat of imports can restrain Ontario refiners from raising prices.

4.4 Potential Price Implications of Regulatory Costs

Before-tax, annualized abatement and monitoring costs per litre of petroleum product were computed to show the maximum potential price increase that would be needed to pass through or recover the regulatory-costs. These values represent costs associated with the Ontario BPT Flow or the Nanticoke Flow BAT Options and are shown as a function of different capacity utilization levels.

Before-tax annualized costs are used in these calculations to show the likely maximum price increases needed to recover these costs over several years. These values are used to assess the impacts on company financial indicators in Chapter 5 and on sector competitiveness in Chapter 6.

Three sets of product-based estimates are computed and displayed in Table 4.3. The first row shows potential cost increases per litre based on the crude oil processing capacity of the 7 Ontario refineries. The second of set of values in row 2 is based on the total Ontario production of refined petroleum products for 1989.

Ratios in row 3 show what the costs per litre would be if the incremental costs were allocated only to the production of gasoline. As shown in row 3, allocating all incremental annualized regulatory costs to gasoline production over the ten-year period for which capital costs are amortized, could add between 0.22 ¢ and 0.47 ¢. to the cost of producing a litre of gasoline.

TABLE 4.3

POTENTIAL MISA-RELATED COSTS PER LITRE OF PETROLEUM PRODUCTS

PRODUCT BASE	BAT OPTION	Cost per Litre of Specified Products based on Refinery Capacity Utilization Rate. (5)				
		100%	90%	80%	78%	70%
		Cents Per Litre				
Total of the Highest Daily Rate of Crude Oil Processed at 7 Ontario Refineries - 1988 to 1990. (35,500,330 M3/Yr)	ONTARIO BPT FLOW (3)	0.077	0.086	0.097	0.100	0.111
	NANTICOKE FLOW (4)	0.117	0.130	0.146	0.150	0.167
Total Ontario Petroleum Products Production for 1989. (32,552,021 M3/Yr) (1)	Ontario BPT FLOW	0.085	0.094	0.106	0.109	0.121
	NANTICOKE FLOW	0.127	0.141	0.159	0.163	0.181
Total Ontario Motor Gasoline Production for 1989. (12,422,879 M3/Yr) (2)	ONTARIO BPT FLOW	0.222	0.246	0.278	0.284	0.317
	NANTICOKE FLOW	0.334	0.371	0.417	0.428	0.477

Notes:
(1) Statistics Canada, Cat. # 45-004
(2) Statistics Canada, Cat. # 45-004
(3) Before-tax annualized cost of Ontario BPT Flow + CAS Option = $23,000,820/yr; includes actual monitoring costs.
(4) Before-tax annualized cost of Nanticoke Flow + CAS Option = $34,547,056/yr; includes actual monitoring costs.
(5) Calculation: ((Cost*1.2)/Production Rate)*(1/Capacity Utilization Rate)
Note: Estimates assume a 20% (i.e., [cost*1.2]) return on investment.

However, if regulation-induced costs are treated as joint costs and applied equally to each litre of product, the unit cost of all products could be increased at most by about 0.17 ¢/l, based on the annualized cost of the Nanticoke BAT Option plus CAS plus the actual cost of monitoring. MISA-induced costs would, therefore, imply price increases of between 0.08 ¢ and 0.47 ¢ per litre to recover all costs over 10 years at present levels of production.

Given the current recession, apparent excess capacity and import competition, it could be argued that even a 0.1¢ per litre permanent price increase could not be achieved. However, if economic recovery is accompanied by increasing product demand, if the exchange rate declines or if industry rationalization includes further reductions in refinery capacity, permanent price increases of up to 0.5¢/l at the refinery level would appear feasible.

Increased product prices, however small, could have several important economic consequences. First, consumers would incur slightly higher costs for petroleum products and would have slightly less income for other goods and services. Second, for those petroleum products whose demand is price elastic, consumption of those products may decline slightly.

Third, other businesses and enterprises would incur higher costs for fuels and other petroleum products which would, in turn, reduce profits or be passed on as slightly higher prices for other goods and services. However, price changes of the magnitude noted in the previous paragraph (0.1¢ to 0.5¢) may not be noticed by consumers against prevailing retail gasoline pump prices (50 ¢ to 60 ¢ per litre).

Whether or not petroleum companies can pass on regulatory costs as higher prices, financial and economic assessments reported in the next two Chapters will assume that **all** potential regulation-induced costs are borne by the regulated plants and the companies that own them. This assumptions will help determine the maximum degree of economic effects that might result from the regulatory program.

5 FINANCIAL ASSESSMENTS OF BAT OPTION COSTS ON PETROLEUM FIRMS AND THE SECTOR

Financial and economic implications of MISA-related abatement costs are analyzed, assuming that all potential abatement and monitoring costs will be absorbed by the regulated firms.

Studies commissioned by the U.S. Environmental Protection Agency to determine which financial indicators best predict single-plant business failures, identified 3 indicators that show a strong correlation with plant closures: return on assets, total debt to total assets, and cash flow to total debt. Industry representatives indicated that total debt to assets, cash flow to total debt and return on capital employed were key financial indicators from their point of view.

Historical financial data were used to analyze these three key financial measures (total debt to assets, cash flow to total debt and return on capital employed) plus 15 other indicators of profitability, solvency, liquidity and efficiency. Potential regulatory cost estimates were used to adjust historical financial data (over the past 10 years) for 4 of the 5 firms that operate Ontario refineries.

Financial impact assessments show that the estimated regulatory costs associated with the highest level of abatement (Nanticoke Flow + CAS) would have imposed changes in various key financial indices (e.g. return on capital employed, debt to total assets) of less than 1%. In particular, these expenses would not push these financial indicators below the levels recorded during the year in which firms experienced their lowest operating profits.

5.1 Data Sources and Limitations

Financial and economic implications of potential MISA-related abatement costs are analyzed in this Chapter, assuming that all potential water pollution abatement and monitoring costs will be absorbed by the regulated firms. Consistent with the draft MISA Issues Resolution Document (June, 1990), financial performance data over the past 10 years were used to assess the potential effects of the relevant monitoring and abatement costs on the sector as a whole, the constituent firms and, where data are available, for business and production units subordinate to the firm.

The draft Issues Resolution Document (June, 1990) states that the "onus" is on "the affected firms" to provide plant-level financial data for such assessments as well as data on expenses incurred as a result of other environmental requirements mandated by the Ministry. Because no plant-level data have been received, analyses presented in this Chapter are based on published data from Statistics Canada, Dun and Bradstreet and the consolidated annual financial reports of each company.

Consolidated corporate financial data are not necessarily representative of individual Ontario plants because consolidated data include revenues and costs of different operational segments (eg. exploration and crude oil production, transportation, refining and marketing) as well as those of operations outside of Ontario. The representativeness of consolidated corporate data is further restricted in the case of the Esso, Nanticoke and the Nova, Corruna refineries because these two plants changed ownership during the past three years. Consolidated financial statements of the parent firms include information concerning these recently acquired refineries for only one or two years.

While plant-specific financial data were not available, corporate financial reports do include disaggregated data for each company's refining, product transport and retail marketing divisions. While the analytical results must be interpreted with care, company divisional/segment data are more representative of refinery financial performance than are consolidated financial data for the entire firm. Consequently, divisional, as well as aggregate sectoral, financial data were used to evaluate financial impacts.

From a public-policy perspective, assessments of the impacts and implications of increased abatement costs at the firm and the industry (or sub-sector) levels are important and useful because:

a. Corporate resources may be available that are not recorded in plant level income statements.

b. The firm, rather than the plant, would have to raise the funds to implement regulatory requirements.

Published financial data for the years 1981 to 1990 have been compiled and collated for analysis. A major structural change occurred in 1985 when crude oil prices were deregulated. Consequently, the last 5 years may, in fact, be the most indicative of economic conditions under which firms are now operating.

The firms that own and operate petroleum refineries in Ontario are each among the largest national and trans-national corporations in Canada. While small business interests are not directly at stake in this sector, many of the retail gasoline stations through which products are sold are small businesses.

5.2 Assessment Methods and Assumptions

Financial assessments presented in this Chapter assume that:

- firms finance potential regulatory-induced capital expenses with debt at 12% per annum, amortized over ten years;
- operating costs are paid out of internal cash flow; (Capital expenses may also be financed as they are incurred out of internal cash flow but the financial impacts in the years during which these expenses are incurred would be greater than under the debt financing scenario);
- capital costs are depreciated on a straight line basis over ten years;
- an accelerated capital cost allowance (ACCA) of 35.9% (i.e., the net present value of the 25%, 50%, and 25% of CCA that is available in years one, two and three respectively) is applied where appropriate[9];

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[9] ACCA Accelerated Capital Cost Allowance is an income tax deduction provided under the (Canadian Government) Federal Income Tax Act for capital expenditures incurred in the course of earning positive business income. The allowance (a tax deduction) is calculated according to rates specified in the Act, which vary depending on the type of capital expenditure. Certain pollution control equipment

- the marginal tax rate used in the analyses is 40%;

For comparative purposes, implications of internal cash flow financing are shown as well.

The basic analytical approach used in this Chapter is to adjust or "shock" **historical financial data** with relevant MISA-related costs (and revenues, if any) to determine how each indicator would have changed if the costs were incurred during that period. The actual computations that are carried used in adjusting company financial data are shown in **Appendix D.**

This assessment considers only the cash requirements to finance potential MISA-induced abatement costs and not the opportunity cost of capital associated with the required funds. Cash requirements defined in this assessment include principal and interest payments for the environmental investments.

A 12% interest rate is used for annualization computations in this analysis. Firms may base their investment choices on a higher expected rate of return than 12%. However, it is not appropriate to base the annualization calculations on desired private rates of return on capital investments because environmental investments yield public rather than private benefits and returns. Moreover, environmental protection investments are often driven by legislative and regulatory mandate. Under these conditions, prevailing market interest rates are the most appropriate measures of the opportunity cost of financing environmental protection actions. Consequently, whether environmental protection expenditures are financed internally through retained earnings or externally through debt, real market rates of interest are most appropriate for annualization or present value calculations.

It would be preferable to compare potential MISA-related compliance costs with

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qualify for an accelerated capital cost allowance (ACCA) which permits full deduction of the expenditure over 3 years (at 25%, 50%, 25% in years 1,2, and 3 respectively).

future financial performance indicators that would apply when the regulatory costs would most likely be incurred. Unfortunately, this analytical approach could not be implemented for the petroleum refining sector because detailed financial forecasts and proforma performance estimates for the industry or for individual firms are not available.

5.3 Financial Indicators and Thresholds

In a prior assessment of the implications of the proposed **MISA monitoring regulations**, the effects of incremental costs associated with monetary returns were evaluated on the basis of three financial indicators:

- after-tax return on investment or capital employed,
- incremental operating costs as a percent of after-tax profits and
- estimated capital expenses as a percent of recorded capital expenditure (Ontario Ministry of the Environment, July 1988).

These indicators were applied because:

1) Where long-term investment decisions are concerned, after-tax return on investment or capital employed represent the return that provides the incentive for owners and investors to keep their capital in a particular enterprise or move their funds to another business that may be more profitable.

2) Incremental operating costs as a percent of after-tax profits show the maximum proportion by which profits could be reduced by the regulatory requirements.

3) Estimated capital expenditures as a proportion of recorded capital expenditures indicate the proportion of a firm's available capital funds that might be diverted away from other uses.

Costs estimates associated with the Nanticoke Flow + CAS BAT Option and the Ontario BPT Flow + CAS Option (plus actual monitoring costs) are used in the financial assessments because they represent cost levels which refineries might incur under a

MISA program. If the costs associated with the highest cost BAT Option (plus MISA-monitoring expenses) do not precipitate severe or undue financial burdens on individual firms, then the less costly BAT Options will be even less problematic for the constituent firms.

About 18 financial measures of profitability, solvency, liquidity and efficiency were analyzed in the present evaluation. In addition, other measures were derived from industry literature, from US EPA experience and from suggestions by industry analysts.

The U.S. EPA commissioned studies to determine which financial indicators and indices best predict single-plant business failure (KPMG Peat Marwick Stevenson & Kellogg, 1990). Three indices were found to have a strong empirical correlation with single-plant business failure: **return on assets, total debt to total assets**, and **cash flow to total debt** (U.S. EPA, 1985). Industry analysts indicated that **return on capital employed** is a particularly good indicator of operating performance for oil refineries. This indicator has been routinely reported by the Petroleum Monitoring Agency (now integrated with Energy, Mines and Resources Canada). Industry experts also suggested that **total debt to total assets, cash flow to total debt** and **return on capital employed** were important financial indicators from their point of view.

Based on these inputs, financial measures, indices and indicators that are used in various analyses are listed in **Appendix D**.

The MISA-related capital, operating and annualized costs for the Nanticoke Flow + CAS BAT Option and Ontario BPT Flow + CAS Option, plus the actual costs of monitoring, were used to "shock" various entries on the profit and loss (income statement) and financial position (balance sheet) data for individual firms and for the sector (as represented by an aggregation of financial data from four of the five firms that own Ontario refineries[10]). Adjustments were made by recalculating the income and balance statements including depreciation, interest payable, principal payable and the ACCA-induced tax savings including MISA-related costs for each firm and for the aggregate sector.

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[10] Financial data for Novacor was not included in the 10-year aggregate "sector" data series because Novacor had only recently acquired the Petrosar refinery. Moreover,

MISA-induced cost estimates were used to adjust three sets of financial performance data:

- average financial performance over the past 10 years,
- financial performance values that were achieved in the year in which the lowest operating income or profit (or the largest operating loss) was recorded over the past 10 years; and
- financial performance for the most recent year for which complete financial data are available, in this case 1990.

Adjustments were carried out on consolidated company data and on certain indicators for disaggregated divisional financial data. Detailed, entry-by-entry descriptions of the adjustment procedures are presented in **Appendix E**. The mitigating influence of the Accelerated Capital Cost Allowance (ACCA) program is also incorporated into the adjustment calculations.

Based on the Issues Resolution Committee Document, adjusted (after MISA costs) 10-year average firm and divisional financial indicators are compared with the recorded values of these indicators for the year in which the firm incurred the lowest before-tax (operational) profit, or largest operating loss, over the past ten years. Similarly, adjusted financial indicators for the most recent year are compared with historical averages for the "industry" and individual firm. The computed, after-cost financial indicators for the most recent year, in this case 1990, and the 10-year averages, were compared and contrasted with corresponding indices of a firm's worst year of net profit performance.

Adjusted ratios and indices may also be evaluated in terms of the magnitude of

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financial data for the Novacor refinery and its previous owner, Polysar, are not publicly available.

change between the "before-cost" and "after-cost" results. For example, a 1% change in a liquidity ratio would be deemed insignificant compared to a 30% change in the same ratio.

Calculated, "after-cost" indices and ratios may also be compared with target values used by firms or by industry analysts to guide investment decisions. However, the subcommittee did not identify or agree on any such target values.

5.4 Financial Consequences

The cost estimates used in the analyses are summarized in Table B-2 in **Appendix B**. These costs include the estimated capital and operating costs for the Nanticoke Flow + CAS and Ontario BPT Flow + CAS BAT Options, augmented by the actual monitoring costs reported by each of regulated firm.

Only aggregate sectoral results using financial data from 4 of the 5 companies that operate refineries are presented in order to avoid revealing competitive information. Results are summarized in Table 5.1a and Table 5.1b for three financial ratios, **cash flow to debt**, **total debt to total assets** and **return on capital employed**. These three indicators are noted here because the subcommittee was advised by industry analysts that these are the most significant indicators of industry performance. As noted, corporate financial data for Novacor were not included because that firm acquired the Corruna refinery (formerly owned by Petrosar) within the past 18 - 24 months and because the bulk of Novacor's enterprise reside in other industries, including oil production, plastics and chemical products, and elsewhere outside Ontario. Firm level results are presented in **Appendix C**.

As shown in Table 5.1a and 5.1b, where it is assumed that firms finance MISA-related capital costs through debt, the changes in sector financial performance due to the Nanticoke Flow + CAS or the Ontario BPT Flow + CAS BAT Options are negligible. In the case of the two solvency indicators (cash flow to debt, total debt to total assets), "before-cost" values are reduced by between 0.1 to 0.3%. Before-cost cash flow to debt and total debt to assets ratios were less favourable for both the average year and the most recent year (1990) when compared to those of 1986, the worst year based on operating profits. Regulation-induced costs do not push sectoral return on capital employed below its 1986 levels.

If the regulated firms finance all of the MISA program costs from retained earnings, over 1 or 2 years, then the estimated capital costs for the Nanticoke + CAS BAT Option would amount to between 1.2 - 3.0 % of the annual capital expenditures before abatement in any of the last 10 years (1981 - 1990).

TABLE 5.1a

SUMMARY RESULTS OF SECTORAL FINANCIAL ASSESSMENT

YEAR		CASH FLOW TO DEBT (%)			TOTAL DEBT TO TOTAL ASSETS (%)			RETURN ON CAPITAL EMPLOYED(%)		
		Before-Cost***	After-Cost	Difference	Before-Cost	After-Cost	Difference	Before-Cost	After-Cost	Difference
NANTICOKE FLOW + CAS	1986*	19.1	-	-	48.0	-	-	4.4	-	-
AVERAGE (1981-1990)		18.7	18.5	-0.2	50.8	51.1	0.3	5.3	5.2	-0.1
1990**		16.0	15.9	-0.1	52.7	52.9	0.2	5.8	5.7	-0.1

* Worst performance in the last 10 years (1981 -1990) based on operating profits.
** Most recent year for which financial performance data are available.
*** Impacts of the Nanticoke BAT Option costs are assessed.

TABLE 5.1b

SUMMARY RESULTS OF SECTORAL FINANCIAL ASSESSMENT

YEAR		CASH FLOW TO DEBT (%)			TOTAL DEBT TO TOTAL ASSETS (%)			RETURN ON CAPITAL EMPLOYED(%)		
		Before-Cost***	After-Cost	Difference	Before-Cost	After-Cost	Difference	Before-Cost	After-Cost	Difference
ONTARIO BPT FLOW + CAS	1986*	19.1	-	-	48.0	-	-	4.4	-	-
AVERAGE (1981-1990)		18.7	18.6	-0.1	50.8	51.0	0.2	5.3	5.2	-0.1
1990**		16.0	16.0	0.0	52.7	52.8	0.1	5.8	5.7	-0.1

* Worst performance in the last 10 years (1981 -1990) based on operating profits.
** Most recent year for which financial performance data are available.
*** Impacts of the Nanticoke BAT Option costs are assessed.

After-cost or adjusted results for individual firms show that, for many indices, no appreciable changes would be recorded. For those indices that were altered, the changes amounted to between 0.1% - 0.3%. With the exception of the measures of solvency, for example, total debt to total assets, the after-cost financial indices of the average year were better than the recorded before-cost financial indices of each firm's respective worst year of operation.

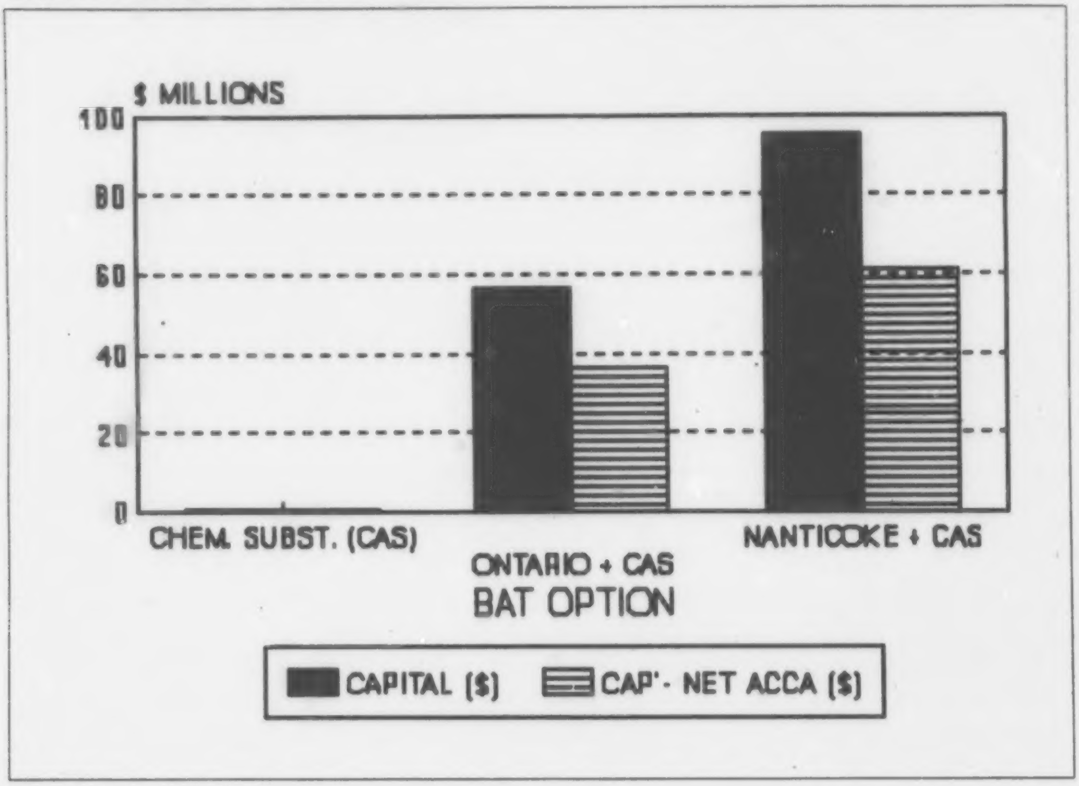
These results incorporate the mitigating effects of the Canadian federal tax system, especially the ACCA. The ACCA may be applied only by firms that make a profit and involves the depreciation of eligible capital items (such as pollution control equipment and energy conservation equipment) at 25% of the capital costs in year 1, 50% in year 2 and 25% in year 3. Over three years, at a corporate marginal tax of 40%, the net present value of the ACCA can result in after-cost savings in capital expenditures of 35.9% in the form of reduced income taxes. A detailed description of the calculation is provided in **Appendix F.**

For those years in which ACCA is claimed, it can be shown that, by incurring capital costs of $57.5 million for the Ontario BPT Flow + CAS BAT Option, the sector can accrue a tax saving of $5.8 million (i.e., $57.5 M X 0.25 X 0.40) in year 1, $11.6 million in year 2 and $5.8 million in year 3. The net present value of these savings over 3 years amounts to $20.6 million being the amount that is foregone income tax revenue to government. Therefore, the total effective capital cost of the Ontario BPT Flow + CAS BAT Option actually borne by the petroleum firms would amount to about $36.9 million ($57.5 - $20.6 million). In the case of the Nanticoke (plus CAS) BAT Option, the effective capital cost to the sector, after accounting for the ACCA, is about $61.8 million ($96.4 - 34.6 million). The effective capital cost reductions from the potential MISA-related capital costs which result from the ACCA are shown in Figure 5.1.

While these mitigating effects will disappear after the firms have used up their ACCA within the time frame specified in the Tax Act, the interest charges on the long-term debt could be reduced if the tax savings were applied towards retiring debt. In addition, pollution control equipment also qualifies for a 30% current cost adjustment under the Ontario Current Cost Adjustment program (OCCA) which can reduce Ontario income taxes payable (Ministry of Treasury and Economics, Ontario Provincial Budget, 1990).

FIGURE 5.1

EFFECTS OF ACCELERATED CAPITAL COST ALLOWANCE ON POTENTIAL CAPITAL COST BY BAT OPTION



None of the threshold values (i.e., financial performance values for the year which registered the lowest operating income over the last 10 years) for any of the companies were breached under the cost of the Ontario BPT Flow + CAS Option or the Nanticoke Flow + CAS Option.

Even when divisional financial data were adjusted with estimated regulatory costs, the changes in the relevant financial performance indicators were less than 1%. In many cases the impacts were negligible. However, in the absence of plant-level data it was inconclusive whether those cost were severe enough to precipitate refinery layoffs or closures if such costs were to have been incurred in any of the last 10 years. It is noted also that some refinery capacities have been shut down during the past 10 years despite the relatively favourable financial performance of the industry (PMA Reports 1981-1990, EMR 1989).

However, there are several uncertainties which will affect the ultimate impacts and responses that firms and plants may make with respect to environmental regulatory requirements. First, the costs of achieving the Nanticoke flow levels may be underestimated for some plants. If this is true, financial and economic effects would be more severe than revealed in the present analyses. Second, integrated petroleum companies face large capital requirements for fuel reformulation, process updates and other environmental protection requirements in Ontario and other jurisdictions. To help deal with growing demands for the diversion of financial resources to environmental protection, industry representatives have asked that various environmental objectives be prioritized. Third, economic recovery has been slow, declining product demand and other economic factors may be more severe than currently expected.

5.5 Implications for the Ontario Environmental Protection Industry

Capital costs consist primarily of equipment purchases and installation expenses. Design and engineering are also included in capital expenses. Operating and maintenance costs generally are comprised of labour and materials or supplies (including energy) expenses. This level of disaggregation was provided in the monitoring cost assessment for the petroleum sector (Ontario, July 1988). With such breakdowns, estimates of the amount of spending that might be directed to Ontario firms could be made.

Although disaggregation of the capital costs into equipment and installation and operating costs into labour and materials/supplies was requested, these breakdowns have not been provided by the technical consultant, SAIC/Apogee (August 1991). It is not possible, therefore, to comment on the extent to which the various potential expenditures for environmental protection might be directed to Ontario firms.

6 IMPLICATIONS FOR COMPETITIVENESS

At the firm level, there are two key factors of competitiveness. First, a company can develop and market new and/or higher quality products or services in order to capture greater market shares or fetch premium prices for its products. Second, a firm's competitiveness can also be enhanced by continuous efforts to discover and implement technological and process changes that reduce production and distribution costs.

At the state/nation level, the July 1989 World Competitiveness Report ranks 22 countries using 292 criteria grouped within 10 categories. This report highlighted environmental protection regulation only in one category as a determinant of competitiveness. In a recent study on Canada's competitiveness, Michael Porter noted that proactive environmental legislation which stressed pollution prevention rather than cleanup could actually promote productivity and competitiveness.

The following measures and aspects of competitiveness that are pertinent to the petroleum refining sector were analyzed:

a. Capacity utilization rates,

b. Relative refinery cost structures and value-added,

c. Environmental protection requirements in Ontario and other jurisdictions.

Review of these factors yields no evidence that the competitive position of Ontario refineries would be adversely affected if they were to incur potential MISA regulatory costs.

6.1 Introduction

In this Chapter, implications of the potential MISA-related abatement and monitoring costs on the competitive position of the Ontario refining sector will be examined.

The measurement of competitiveness is an illusive task. According to the **World Competitiveness Report**, prepared by the Institute Etude Methods Direction Enterprises (IMEDE) and the World Economic Forum, "Competitiveness is the ability of entrepreneurs to design, produce and market goods and services, the price and non-price qualities of which form a more attractive package than that of competitors" (Garelli, July 1989). David Vice (March-April, 1988) of Northern Telecom Ltd. argues that "competitiveness means doing everything efficiently, and with as much innovation and inspiration as we can possibly bring to the job."

The World Competitiveness Report (July 1989) annually ranks the competitiveness of 22 countries using 292 criteria which are grouped into ten categories. While environmental protection regulations are a component of "government regulations," this factor was not singled out as a particularly important or problematic issue. In a study of Canada's competitiveness for the Conference Board of Canada, Johnston (Feb. 1990) cites the following key factors as important to competitiveness: R&D spending, productivity, human resources development, customer satisfaction, flexible organizational structures, critical self- analysis, creativity, and enhanced intelligence gathering capabilities. Environmental regulatory activity was not included in this list of key issues for competitiveness.

There are two key aspects of competitiveness to which firms and even public agencies must be attuned. The first refers to the ability of a firm to develop and market new and/or higher quality products or services which can attract greater market shares and/or premium prices. Alternatively, competitive firms constantly try to discover and implement technologies or process changes that reduce the costs of producing and distributing existing products in order to gain or maintain existing market shares and sales levels.

The first aspect of competitiveness involves taking steps to enhance the demand and associated revenues for new goods and services. The second aspect concerns reducing the costs of existing goods and services that the firm produces relative to competing firms.

Petroleum products are highly standardized and are being sold in mature markets, some of which are actually declining. Consequently, the focus of this Chapter is on the relative production costs of refineries and how potential MISA-related costs might affect the average and marginal production costs at Ontario refineries. Therefore, refinery costs structures and value-added measures for Ontario refineries are compared with estimates for competing refineries in other provinces and the U.S. In addition, capacity utilization rates for refineries will be compared as an indication of the relative competitiveness of the various plants. Finally, the extent to which environmental protection requirements on refineries in other jurisdictions compare with those proposed for Ontario will be noted.

In a recent study by M.E. Porter on the productivity of Canadian industry, the following observations about environmental standards and competitiveness were noted (Porter, 1991):

> *"Strict, anticipatory regulatory standards can be a potent force for spurring upgrading in industry provided they are designed and administered effectively. ... Tough standards for energy efficiency and environmental impact trigger innovations in products and processes that are highly valued elsewhere."*

Porter's article further observed that:

> *"The Conflict between environmental protection and economic competitiveness is a false dichotomy . . . Strict environmental regulations do not inevitably hinder competitive advantage against foreign rivals: indeed they often enhance it."*

Porter partially explained the poor competitive position of some Canadian industrial sectors as due to the:

> *"Lack of consistent regulatory pressure has allowed some Canadian firms to avoid aggressively upgrading their technology which would also generate productivity increases."*

Economic competitiveness and renewal activities in Ontario have linkages with the environmental protection measures proposed for the province. The increased focus on pollution prevention and the 3R's by the MISA program is consistent with a strong competitive position for Ontario industries as Porter observed in the cited article:

> *"Turning environmental concerns into competitive advantage demands the right kind of regulations. They must stress pollution prevention rather than abatement or cleanup."*

6.2 Capacity Utilization

Petroleum refineries are capital-intensive operations with high fixed costs. Consequently, once a refinery is installed and operating, the marginal or incremental costs of increasing output are very low. Other than the cost of the crude to be processed and of additional chemicals and energy, the costs of operating a refinery at 70% capacity are roughly the same as operating it at 90% capacity. Therefore, the larger the throughput of crude oil processed per unit time, the lower the average or unit costs and the more profitable the operation. Fesharacki and Isaak (1985) suggest that the most profitable levels of operation are at 93 to 94% of nominal design capacity. Operating at the 90-95% level allows refiners the flexibility to increase output when needed to meet demand or to accommodate unplanned interruptions in production for repairs (Restrictive Trade Practices Commission, 1986).

The capacity utilization rate is, therefore, a key measure by which oil companies monitor and compare their performance with competitors. If low capacity utilization rates persist at some refineries, unit costs will be measurably higher than competing refineries that operate at higher utilization rates. As shown in Table 6.1, Ontario's refinery capacity utilization rate has been consistently below that of Quebec and Canada as a whole but generally higher than the average for refineries in the U.S. Therefore, Ontario refineries are operating at less efficient levels relative to Quebec refineries, this is also reflected in Ontario refineries lower margins discussed later in this Chapter.

Capacity utilization rates may be improved by increasing petroleum product sales (the numerator of the ratio), or by reducing the overall nominal refining capacity (the denominator of the ratio). Individual firms generally can have little effect on the overall volume of petroleum product demand and sales although they attempt to increase market share with advertising. On the other hand, refining capacity has been closed down by oil companies in Canada and Ontario so that the capacity utilization rate for the remaining capacity may be increased.

TABLE 6.1

AVERAGE CAPACITY UTILIZATION RATES OF REFINERIES IN DIFFERENT JURISDICTIONS

YEAR	USA(1)	ONTARIO	QUEBEC	CANADA
	AVERAGE CAPACITY UTILIZATION RATES (%)			
1980	74.9	89.2	80.9	97.8
1981	67.0	73.0 (2)	80.0	79.0
1982	65.8	70.7	78.4	72.0
1983	69.3	80.7	89.8	76.7
1984	74.6	85.5	82.2	78.3
1985	76.6	(4)	(4)	(4)
1986	82.9	(4)	(4)	(4)
1987	83.1	77.0 (3)	84.0	81.0
1988	84.4	83.7	91.8	85.5
1989	86.3	89.1	92.8	88.5

(1) Pennwell, U.S. Petroleum Review, 1987
(2) Energy, Mines and Resources Canada, Petroleum Processing in Canada, December 1987.
(3) Energy, Mines and Resources Canada, Oil and Gas Branch.
(4) Data not available.

Total crude oil refining capacity in Canada and Ontario has declined between 1978 and 1987 (Energy, Mines and Resources Canada, Dec. 1987, p. 26). Total Canadian refining capacity fell from 384,000 m^3/d in 1978 to 303,000 m^3/d in 1987; Ontario refinery capacity declined from 130,000 to 100,700 m^3/d during the same period. The number of operating refineries in Canada declined from 38 to 29 during the same period and, in Ontario, from 9 to the 7 that are currently operating.

Most of the contraction in refining capacity during this period took place in Quebec where total crude oil capacity was reduced by about 50,000 m3/d (i.e., 50% of the total capacity reductions in Canada) and where 4 refineries were closed. The remaining refinery closures (2 plants) occurred in Ontario. These closures are, in part, attributed to slow growth (or absolute declines) in the consumption of petroleum-based fuels during the 1980's. These closures also occurred in spite of the relatively favourable performance values that were recorded by firms in the sector.

Companies close down refining capacity with the intent that the remaining operations would be more efficient and profitable. In some cases, this is accomplished by shutting down smaller plants. The three remaining refineries in Quebec have an average processing capacity of 16,400 m3 of crude oil per day. Ontario refineries are somewhat smaller, averaging about 14,400 m3/d, which has not changed over the entire 1978-1987 period (Energy, Mines and Resources, Dec. 1987). Likewise, Ontario refineries have lower capacities compared to their U.S. competitors, as shown in Table 6.4.

Based on studies and assessments of MISA-related monitoring activities and potential abatement technologies, there does not appear to be any direct effects of these activities on capacity utilization rates although, as noted, the unit costs of production would be increased slightly (VHB/CH2M Hill, May 1991; SAIC/Apogee, August 1991; Ontario Ministry of the Environment, July 1988).

In 1990, as Table 6.2 shows, 22% of Ontario's production was consumed outside the province. This dependence on export is why when Ontario domestic sales volume for petroleum products dropped by 9% between 1980 and 1989, from 31 million cubic meters per year (m^3/yr) to 28 million m^3/yr, refinery production only declined by 7% (from 35.1 million m^3 to 32.6 million m^3) (Energy, Mines and Resources Canada, 1987; Environment Canada, 1987; 1990). Capacity utilization rates would otherwise be much lower if the refineries depended solely on the Ontario market for the sale of their products. As was evident in Figures 4.2 and 4.3, exports of petroleum products from Ontario refineries expanded and remained strong over the period 1980 to 1989. In 1989, exports of petroleum products amounted to 10% of total Ontario refinery output or 3.3 million m^3. Imports during that period remained at about 1 million m^3 per year. According to the data shown in Figure 4.3, imports of gasoline exceeded exports only during 1988. Virtually all of these products were exported to the U.S.. Table 6.2 shows that Ontario's production of refined petroleum products during 1990 exceeded domestic consumption of those products. Furthermore, inter-provincial trade (transfers and receipts) in refined petroleum products appears to be more important, in terms of volume, than international trade (imports and exports of refined products) between Ontario and United States.

TABLE 6.2

1990 SUPPLY AND DEMAND FOR REFINED PETROLEUM PRODUCTS IN ONTARIO

Refined Petroleum Products	Ontario Production	Transfers to Other Canadian Provinces	Receipts from Other Canadian Provinces	Exports	Imports	Ontario Domestic Sales	Ontario Sales From Ontario Domestic Production (%)
	(Thousand M^3 per day)						
GASOLINE	31.9	2.2	4.5	1.3	0.6	34.3	29.1 (92%)
ALL PRODUCTS	76.9	8.9	15.4	8.4	2.4	75.7	59.6 (78%)

Source: Adapted from Purvin & Gertz (September, 1991).

Access to the U.S. market, and particularly for products other than gasoline, has not only helped Ontario refineries maintain higher capacity utilization rates but also to be profitable. It would appear that Ontario refineries are holding their market share against competitors in the U.S for non-gasoline products. While in the Ontario market, the threat of increased gasoline imports from the U.S. appears to constrain Ontario's refiners ability to reduce operating capacities and increase prices. Any curtailment or shortfall in Ontario gasoline would be quickly supplied by imports, which current have the capacity to supply 20% of that markets demand. It is not apparent, however, that the added costs of potential BAT Options would affect these competitive factors or marketing patterns.

6.3 Value Added and Refinery Margins

Value Added is the value of products sold at a particular vertical level of production, less the cost of input materials and energy used in the production process. The remaining value is thus equal to the value of the labour input plus the "surplus" or profit for the firm or industry at a specific vertical production level. Value added is an important measure of the value that a plant or firm contributes to the local community (e.g., wages, goods and services bought).

Therefore, the difference between the price of a cubic metre (m^3) of refined product and the cost of a m^3 of crude plus the costs of energy and chemical additives is of particular interest to provincial and local governments as well as to the oil companies.

Estimates of the annual average, before-tax value added per litre of petroleum products for refining and marketing operations in Ontario, Quebec and Canada as a whole are summarized in Table 6.3. These figures show that the average value added at Ontario refineries declined between 1984 and 1986 and dropped below average levels for Quebec refineries and for all of Canada. In the latest year for which figures are available, 1986, Ontario's value added levels are somewhat closer to the national averages than are those for Quebec refineries.

TABLE 6.3

VALUE ADDED PER LITRE OF PRODUCT

YEAR	ONTARIO[1]	QUEBEC[1]	CANADA[1]
	CENTS PER LITRE		
1980	1.74	1.86	1.55
1981	3.83	3.00	2.53
1982	2.89	2.25	2.34
1983	3.60	2.76	2.97
1984	2.76	3.97	2.85
1985	1.99	3.29	2.86
1986	1.95	3.73	2.05

1. Source: Adapted from Statistics Canada: Cat. 45-004, Supply and Disposition of Petroleum Products; Cat. 31-203, Industries Principal Statistics.

As was shown in Table 4.3, MISA-related, before-tax costs could amount to about 0.11 - 0.16 cents (¢) per litre (at 78% capacity utilization) for all products or 0.28 - 0.43 cent (¢) per litre if these MISA-induced costs are applied only to gasoline. Note that these estimates assume a 20% return on investment. Thus, MISA-related costs could reduce the value added (and gross margin estimates) at Ontario refineries by at most, 0.16 cents (¢) per litre for all products (and 0.43 ¢ if all cost increases were diverted to gasoline). This range of price increases would amount to between 0.6% to 1.6% of refinery gate price (26.2 ¢/l)[11] for premium unleaded gasoline. It is worth noting that in 1990, the average profit of Canadian petroleum products industry was approximately 0.75 ¢/litre (Paquet, 1992). If refiners were to absorb the potential cost increases (i.e., 0.16 or 0.43 ¢/litre), the increase cost would represent 21% and 57% drop respectively in sector's 1990 profit.

Crude oil prices are a key cost to a refinery. A recent study indicates that net feedstock costs for the petrochemicals and petroleum refining industries can amount to over 50%, and in some cases as high as 66% of the total operating expenses (Paquet, 1991). Refineries purchase crude oil at varying prices which reflect the quality of crude and cost of transportation. Refineries in Ontario predominately use higher price light crude oil in their operations. The capacity of Ontario refineries to use cheaper heavy crude oils is limited, while U.S. refiners have large facilities which can use the currently lower-priced heavy crudes. As current Western Canada sources of light crudes "dry-up", Ontario refineries would come to depend increasingly on imported light crude, albeit at even higher costs when transport costs are added.

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[11] 26.2 ¢ is the average price Ontario refineries sold premium unleaded gasoline to private brand resellers in 1990 (see PMA 1990, page 54, Table A10)

Table 6.4 shows crude oil types used by Ontario and U.S. refineries located in States adjoining the Great Lakes. It should be noted that, in addition to having over twice (218%) the capacity of Ontario refineries, the U.S. Great Lakes refineries devote a larger proportion of their refining capacity to heavier and cheaper crudes. It is estimated that, if the current dependence on light crudes continues and without any increase in heavy crude refining capacity, by the year 2005 about 60% of all crude used by Ontario refineries would be imported light oil (Purvin & Gertz, 1991). The cost of converting an average light crude refinery to a heavy crude refinery is estimated at CDN $ 700 million (Purvin & Gertz, 1991). The current slowing demand for refined products in Ontario and the industry's worsening income performance would influence industry's investment decisions.

TABLE 6.4

CRUDE OIL TYPES USED BY ONTARIO AND U.S. GREAT LAKES REFINERIES: 1990.

REFINERY	LOCATION	CRUDE TYPE	CAPACITY (m3 per day)
ONTARIO*			
Esso	Sarnia	Light, Medium Heavy	19,841
Esso	Nanticoke	Light	18,571
Shell	Sarnia	Light, Medium	11,270
Petro-Canada	Oakville	Light, Heavy	11,587
Petro-Canada	Mississauga	Light	7,302
Suncor	Sarnia	Synthetic, Light	11,905
Nova	Corunna	Light	14,603
	TOTAL CAPACITY →		95,079
	AVERAGE CAPACITY →		13,583
U.S. Great Lakes**			
Sun Refining	Toledo, OH	Light, Synthetic	19,207
B.P	Toledo, OH	Light	22,699
Marathon	Detroit, MI	Light, Heavy	10,873
Total	Alma, MI	Light	7,238
United Refining	Warren, PA	Light	10,254
Clark Oil	Blue Island, IL	Light	10,635
Mobil Oil	Joliet, IL	Light, Medium, Heavy	28,572
Unoven	Lemont, IL	Light, Medium, Heavy	23,334
Amoco	Whiting, IN	Light, Medium, Heavy	55,556
	TOTAL CAPACITY →		188,368
	AVERAGE CAPACITY →		20,930

Sources: * SAIC et al, (May 1991)
** Purvin & Gertz (September, 1991)

As shown in Table 6.5, delivered costs of crude oil at Sarnia are slightly lower than in Toronto because Sarnia is closer to Alberta and Saskatchewan. Crude oil costs confer locational advantages to refiners. The closer a refinery is to the wellhead or to large shipping ports, the lower the transportation portion of its crude costs. Ontario refiners, therefore, pay more for Western Canadian crude oil than refineries located in the Prairies and British Columbia but less than refineries in Quebec. Reversal of "Inter-Provincial Line 9" the Sarnia-Montreal pipeline will enable Ontario refiners to access lower cost import crude necessary to satisfy the potential shortfall in (Western Canada) sweet crude.

TABLE 6.5

CRUDE OIL COSTS IN USA AND SELECTED CANADIAN LOCATIONS

YEAR	AVERAGE USA(1)	SARNIA ONTARIO(2)	TORONTO ONTARIO(2)	MONTREAL QUEBEC(2)	EDMONTON PRAIRIES(2)
	CDN $ PER CUBIC METRE (M^3)				
1980		113.96	113.71		109.12
1981		173.70	174.06		168.81
1982		210.18	210.18		204.05
1983		227.21	227.65		220.76
1984		230.10	230.54		223.54
1985		241.01	241.45	242.45	234.29
1986	129.87	131.76	132.22	133.49	124.47
1987		156.03	156.03	158.59	148.44
1988		119.69	120.27	121.84	112.35
1989		141.05	141.67	143.34	133.62

Source: (1) Pennwell Publishers, 1987.
(2) Energy, Mines and Resources Canada, 1990, Energy Statistics Handbook.

Between 1978 and 1987, about 62% or 50,000 m3/d of the 81,000 m3/d reduction in Canadian refining capacity occurred at the expense of Quebec refineries, which were subject to higher crude oil costs relative to other major refining centres in Canada. This experience emphasizes the importance of the availability and access of reasonably priced crude oil are to refiners competitive positions.

6.4 Environmental Protection Activities in Other Jurisdictions

To the extent that Ontario environmental requirements exceed those applied in jurisdictions where competitors are located, Ontario refineries could be at a competitive disadvantage. However, environmental requirements in other jurisdictions have been reviewed by James F. Hickling Management Consultants (1990) who concluded that:

> *"In our view, all the jurisdictions[12] examined will continue to impose ever-more stringent regulation of industries' toxic pollutants."*

Moreover, regarding capital investments for environmental abatement, the Hickling report states that Canadian-based companies have an advantage relative to their United States counterparts.

> *"Firms operating in Canada, however, have a significant advantage over their U.S. counterparts in the Canadian federal government's accelerated capital cost allowance that the Canadian firms are permitted on their purchases of equipment for the purposes of pollution abatement and control. U.S. companies have no such comparable program."*

This advantage has been accounted for in the calculations in Chapter 5 of this report.

In addition, refineries in Quebec and Alberta are currently subject to a variety of regulatory requirements that are similar to those obtaining in Ontario (Losier, 1990). In Quebec at least, authorities are developing new regulatory requirements that are comparable to the MISA program. Air and water toxics regulations and enforcement regimen in Japan appear to be considerably more stringent than those in place in Ontario (Hickling, 1990).

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[12] Ontario, Quebec, Alberta, U.S. Federal, 12 U.S.(American) States, and 6 OECD countries (including Japan).

7 FINDINGS AND CONCLUSIONS

The analyses presented in this report are based on potential combinations of abatement technologies and their associated costs that are technically feasible at each refinery. Albeit, there are uncertainties regarding the installation and retrofit of the Nanticoke Flow Option at some refineries. The contaminants for which reductions are estimated and the loading levels to which these contaminants are reduced reflect technical possibilities rather than proposed effluent limits on specific compounds. However, cost functions and other information developed in this report can be used to evaluate the cost implications of specific loading limits once they are proposed.

7.1 Findings

Initial loadings based on the MISA effluent monitoring data total 624 tonnes per year of Total Suspended Solids + Oil & Grease and 6 tonnes of seven toxic contaminants (phenols, chromium, zinc, benzene, m- & p-xylene, o-xylene and toluene) from the 7 refineries subject to MISA regulations.

Combinations of technologies that could be applied at each of the seven Ontario refinery to reduce contaminant loadings were postulated. Estimates of pollutant reductions for 13 contaminants and their associated costs were developed for each technology combination at each refinery.

The lowest cost technical option, Chemical Additive Substitution (CAS), was estimated to remove 4.2 tonnes (or 68%) of two (zinc and chromium) of the above-noted seven persistent toxic chemical loadings from 5 of the 7 refineries. Estimated before-tax annualized costs total $472,000 over ten years (including $1 million in capital expenditures and $295,000 per year in operating expenses). No conventional pollutants would be removed by the CAS technology. It appears that the 5 refineries that can implement these additive substitutions have done so as of this writing.

The next level of incremental reductions can be achieved by the Ontario BPT Flow technology combinations applied to each refinery. Alone, this option can remove 337 tonnes or 25% of the conventional contaminants and an additional 0.95 tonne or 1.54% of the persistent toxic contaminants at a before-tax annualized cost of $18 million per year, based on $8.3 million of annual operating costs and $56.5 million capital cost for all Ontario refineries amortized over 10 years. Combined with the CAS technology, the Ontario BPT Flow technologies could achieve a **total** reduction of 391,000 kg/yr or 29% of conventional pollutants (ie. TSS, DOC, Ammonia, Oil & Grease, sulphides, VSS) and 4,400 kg/yr or 71 % of persistent toxics.

A third BAT Option, the Nanticoke equivalent flow, could, by itself, achieve a further 12% or 157 tonnes reduction of conventional pollutants and an additional 11% or 0.66 tonne reduction of the 7 persistent toxic compounds. Application of this set of technologies at each plant, combined with the CAS technology, involves the highest costs for the 7 refineries, totalling $95.5 million in capital and an annualized cost of $29.8 million over 10 years. Cost estimates for this BAT Option may be under-stated because site-specific characteristics at each refinery may involve more costly retrofitting than indicated by the Ministry consultants.

About 547 tonnes (41%) per year of conventional contaminants and 5 tonnes (82%) per year of toxic contaminants could be reduced from Ontario refineries by this BAT Option combination.

Based on the unit cost per kilogram of contaminant loadings removed, the Chemical Additive Substitution (CAS) BAT Option is the most cost-effective option ($92/kg removed) to remove toxic contaminants. The Nanticoke Flow Option by itself is the next cost-effective BAT Option to remove toxics ($35,263/kg removed) after CAS while the Ontario BPT Flow BAT Option appears to have the highest cost per kilogram removed.

However, when the CAS technology is combined with each of the other BAT Options, the Ontario BPT Flow + CAS combination is more cost-effective ($4,255/kg removed) than the Nanticoke Flow + CAS combination ($5,988/kg removed).

The Ontario BPT Flow Option is definitely the more cost-effective ($83/kg) than the Nanticoke Flow BAT Option ($102/kg) for reducing conventional contaminants.

The annualized cost per litre of petroleum products for the highest cost BAT Option (Nanticoke + CAS) applied to each refinery amounts to between 0.127 ¢ and 0.181 ¢, depending on the level of refinery utilization.

Individual Ontario refineries or firms currently have limited ability to pass on cost increases as higher prices to wholesalers and retailers. This is inability caused by of competition from importers that bring U.S. products into Ontario, primarily gasoline, and the over-all demand for petroleum products has been declining during the past decade.

Using costs associated with the highest cost BAT Option (Nanticoke + CAS) costs plus reported monitoring costs already expended by regulated plants, comparisons of "After-cost" estimates with "Before cost" financial data were made of three key indicators for the sector and for individual oil companies, return on capital employed, the ratio of cash flow to debt and cash flow to net income. These comparisons reveal only small potential reductions (between 0.1. % and 0.2 %) in the indicators. Moreover, financial indicators that incorporate estimated regulatory costs associated with the Nanticoke Flow + CAS Option produced "After-cost" financial indicators which were not lower than any of the financial performance values recorded for the year with the worst operating income (profit).

For purposes of the present study, the following measures of competitiveness were analyzed.

a. Capacity utilization rates,

b. Relative refinery cost structures and value-added,

c. Environmental protection requirements in other jurisdictions.

There are no small businesses liable for regulation in this sector.

7.2 Conclusions

The estimated costs of implementing the highest cost technology combinations at each plant (Nanticoke equivalent + CAS BAT Option) plus actual monitoring costs would not likely cause undue financial hardships for any of the firms in the sector. There is no evidence that, by themselves, these costs would precipitate refinery closures. These conclusions apply to the Ontario BPT and the CAS BAT Options whose costs are lower than the Nanticoke + CAS Option.

Permanent price increases of between 0.127 and 0.181 cent (¢) per litre of product could be achieved without attracting increased imports if growth in demand were to resume and/or after oil companies complete planned restructuring activities that may involve reduction in refinery production capacity. Moreover, prices of gasoline and home heating fuels are generally price inelastic in the short run (less than one year) so that small price increases may be applied without significantly affecting total quantity of refined petroleum products consumed.

Because disaggregations of the capital costs and of operating costs were not provided, it is not possible to comment on the extent to which expenditures associated with the various levels of abatement might be directed to Ontario-based suppliers of environmental protection equipment and services.

Analyses indicate that Ontario refineries could achieve an additional 60% - 80% removal of the contaminants currently being discharged without significant financial or competitive impairment to the regulated firms.

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APPENDIX A

MEMBERS OF THE PETROLEUM SECTOR ECONOMIC ASSESSMENT AND BAT SUBCOMMITTEES

TABLE A.1

MISA JOINT TECHNICAL COMMITTEE FOR THE PETROLEUM REFINING SECTOR ECONOMIC ACHIEVABILITY SUBCOMMITTEE

NAME	ORGANIZATION	TELEPHONE
BOWER, Barry	Ministry of Energy	(416) 327-1468
GREENWOOD, Libby	Environment Canada	(819) 953-1659
DONNAN, Jack	Ministry of the Environment	(416) 323-4579
JOHNSON, Ian (Chair)	Ministry of the Environment	(416) 323-4557
LUYT, John	Ministry of the Environment	(519) 336-4030
SHEFFIELD, Arthur	Environment Canada	(819) 953-1172
THORNTON, Nada	Ministry of the Environment	(416) 323-4850

TABLE A.2

MISA JOINT TECHNICAL COMMITTEE FOR THE PETROLEUM REFINING SECTOR BEST AVAILABLE TECHNOLOGY (BAT) SUBCOMMITTEE

NAME	ORGANIZATION	TELEPHONE
AHMED, Aziz	Ministry of the Environment	(416) 440-3721
BARBEAU, Gilles	Esso Petroleum Canada	(416) 968-4820
COUSENS, Roger	Petro-Canada Ltd	(416) 849-5323
GRATZER, Paul	Ministry of the Environment	returned to graduate school - University of Toronto
JOHNSON, Ian	Ministry of the Environment	(416) 323-4557
LITTLE, Tim	Ministry of the Environment	(519) 336-4030
MELCER, Henryk	Environment Canada	(416) 336-4546
THORNTON, Nada (Chair)	Ministry of the Environment	(416) 323-4850

APPENDIX B

INPUT DATA FOR COST ESTIMATIONS

Table B.1

INITIAL CONTAMINANT LOADINGS BASED ON MISA MONITORING, CRUDE OIL CAPACITIES AND WASTEWATER FLOWS

ONTARIO REFINERIES	CONTAMINANTS LOADINGS													CRUDE OIL PROCESSING CAPACITY m3/day*	WASTEWATER FLOW m3/day**
	TSS (KG/YEAR)	DOC (KG/YEAR)	OIL&GREASE (KG/YEAR)	AMMONIA + AMMONIUM (KG/YEAR)	SULPHIDE (KG/YEAR)	VSS (KG/YEAR)	PHENOLS (KG/YEAR)	CHROMIUM (KG/YEAR)	ZINC (KG/YEAR)	BENZENE (KG/YEAR)	TOLUENE (KG/YEAR)	m - & p - XYLENE (KG/YEAR)	o - XYLENE (KG/YEAR)		
ESSO (SARNIA) INITIAL (PRESENT) LOADINGS	125,743	100,985	11,403	4,417	308	108,792	33	0	177	17	25	30	22	19,873	28,099
ESSO (NANTICOKE) INITIAL (PRESENT) LOADINGS	16,171	16,351	4,079	569	82	9,837	9	21	65	0	0	0	0	18,601	6,548
NOVA (CORUNNA) INITIAL (PRESENT) LOADINGS	35,135	33,784	3,859	1,308	472	19,025	12	524	934	0	0	0	0	10,454	5,835
PETRO-CANADA (MISSISSAUGA) INITIAL (PRESENT) LOADINGS	87,958	45,399	16,320	10.080	320	42,359	36	502	364	0	0	0	0	7,313	10,923
PETRO-CANADA (OAKVILLE) INITIAL (PRESENT) LOADINGS	36,422	30,092	3,576	7,814	286	24,675	71	158	2,539	2	1	2	7	11,600	4,899
SHELL (SARNIA) INITIAL (PRESENT) LOADINGS	241,503	77,748	14,918	1,458	97	145,922	29	142	167	7	6	6	3	11,287	13,292
SUNCOR (SARNIA) INITIAL (PRESENT) LOADINGS	22,709	23,958	3,418	4,535	66	14,592	20	65	170	2	2	2	2	11,923	8,994
INITIAL (PRESENT) LOADINGS	565,642	328,317	57,572	30,180	1,630	365,202	209	1,414	4,416	27	33	40	34	91,051	

* Highest daily rate (1986 - 1990).
** Average daily MISA-monitoring flow (Dec. 1988 - Nov. 1989).

Source: Monitoring Data were provided by the Water Resources Branch, MISA Industrial Section.

Table B.2

SUM CF BAT OPTION COST ESTIMATES AND ACTUAL MISA COSTS OF MONITORING USED IN FINANCIAL ASSESSMENT MODELS

REFINERIES AND SOURCE TREATMENT PLANS		BAT OPTION COST ESTIMATES			ACTUAL COST OF MISA MONITORING			COMBINED ANNUALIZED COSTS	
BAT OPTION	TECHNOLOGIES	CAPITAL ($)	O&M ($/YEAR)	ANNUALIZED ($/YEAR)	CAPITAL ($)	O&M ($/YEAR)	ANNUALIZED ($/YEAR)	BEFORE-TAX ($/YEAR)	AFTER-TAX ($/YEAR)
ESSO, Sarnia									
CHEMICAL SUBST.					397,754	330,491	240,532	400,887	240,532
ONTARIO BPT FLOW	FRN, DAF, PND, EQN	26,789,490	4,348,960	5,454,165	397,754	330,491	240,532	9,491,163	5,694,698
NANTICOKE FLOW	FRN, DAF, PND, EQN	42,561,990	6,381,860	8,348,795	397,754	330,491	240,532	14,315,545	8,589,327
ESSO, Nanticoke									
		-	-	-	82,220	243,224	154,665	257,775	154,665
SUNCOR, Corunna									
CHEMICAL SUBST.	CAS	200,000	84,000	71,638	563,266	245,320	207,005	464,407	278,644
ONTARIO BPT FLOW	CAS, FLT, PND	2,885,855	318,651	497,641	563,266	245,320	207,005	1,174,410	704,646
NANTICOKE FLOW	CAS, FLT, PND, FRN	6,823,355	826,151	1,220,266	563,266	245,320	207,005	2,378,787	1,427,272
PETRO-CANADA, Miss.									
CHEMICAL SUBST.	CAS	200,000	53,000	53,038	58,861	368,720	227,482	467,535	280,521
ONTARIO BPT FLOW	CAS, DAF, PND	7,393,242	965,448	1,364,361	58,861	368,720	227,482	2,378,787	1,591,843
NANTICOKE FLOW	CAS, DAF, PND, FRN	14,896,992	1,595,096	2,38,977	58,861	368,720	227,482	4,610,765	2,766,459
PETRO-CANADA, Oak.									
CHEMICAL SUBST.	CAS	200,000	60,000	57,238	95,100	346,075	217,744	458,303	274,982
ONTARIO BPT FLOW	CAS, FRN	325,000	125,000	109,512	95,100	346,075	217,744	545,427	327,256
NANTICOKE FLOW	CAS, FRN	1,838,125	320,025	387,206	95,100	346,075	217,744	1,008,250	604,950

Table B.2 cont.

SUM OF BAT OPTION COST ESTIMATES AND ACTUAL MISA COSTS OF MONITORING USED IN FINANCIAL ASSESSMENT MODELS

REFINERIES AND SOURCE TREATMENT PLANS		BAT OPTION COST ESTIMATES			ACTUAL COST OF MISA MONITORING			COMBINED ANNUALIZED COSTS ($/YEAR)	
BAT OPTION	TECHNOLOGIES	CAPITAL ($)	O&M ($/YEAR)	ANNUALIZED ($/YEAR)	CAPITAL ($)	O&M ($/YEAR)	ANNUALIZED ($/YEAR)	BEFORE-TAX	AFTER-TAX
Shell, Sarnia									
CHEMICAL SUBST.	CAS	200,000	22,000	34,438	222,538	407,132	267,911	503,915	302,349
ONTARIO BPT FLOW	CAS, FLT, PND, FRN	16,821,980	2,146,527	3,074,251	222,538	407,132	267,911	5,570,268	3,342,161
NANTICOKE FLOW	CAS, FLT, PND, FRN	20,275,730	2,591,672	3,708,093	222,538	407,132	267,911	6,626,673	3,976,004
Suncor, Sarnia									
CHEMICAL SUBST.	CAS	200,000	76,000	66,838	416,000	295,520	221,487	480,542	288,325
ONTARIO BPT FLOW	CAS, FLT, PND, FRN	2,288,333	417,636	493,581	416,000	295,520	221,487	1,191,780	715,068
NANTICOKE FLOW	CAS, FLT, PND, FRN	8,959,583	1,277,486	1,717,914	416,000	295,520	221,487	3,232,335	1,939,401
SECTORAL TOTALS BY BAT OPTIONS	CHEMICAL SUBSTITUTION	1,000,000	295,000	283,190	1,835,739	2,236,482	1,141,630	3,033,363	1,820,018
	ONTARIO BPT FLOW	57,503,900	8,6617,222	11,276,701	1,835,739	2,236,482	1,141,630	21,333,895	12,800,337
	NANTICOKE FLOW	96,355,775	13,287,290	18,204,441	1,835,739	2,236,482	1,141,630	32,430,130	19,458,078

KEY:
DAF = DISSOLVED AIR FLOTATION
FLT = FILTER
PND = POLISHING POND
EQN = EQUALIZATION
FRN = FLOW REDUCTION (SOURCE CONTROL)

TABLE B.3

ONTARIO REFINERY PROCESS WASTEWATER FLOW RATIOS (EPA BPT/BAT FLOWS VERSUS MISA ACTUAL FLOWS)

REFINERY	EPA COMPLEXITY CATEGORY	FLOW (U.S. gallons/barrel)			FLOW RATIO	
		MISA	EPA		MISA/BPT	MISA/BAT
		ACTUAL	BPT	BAT		
Esso - Sarnia	D	66	72	46	0.92	1.43
Esso - Nanticoke	B	15	31	24	0.48	0.63
Novacor - Corunna	C	21	32	29	0.69	0.74
Petro-Canada - Mississauga	D	69	58	44	1.19	1.57
Petro-Canada - Oakville	B	19	28	21	0.68	0.90
Shell - Sarnia	C	54	27	24	2.00	2.25
Suncor - Sarnia	C	34	32	33	1.06	1.03

EPA Refinery Complexity increases from A to E: A = Topping; B = Cracking + A, C = Petrochemical + A + B; D = Lube + A + B; E = Integrated (A + B + C + D).

Source: Science Applications International Corporation (SAIC), 1991.

Table B.4

Final Contaminant Loadings By Refinery And BAT Option.

SOURCE TREATMENT PLAN		COSTS			FINAL CONTAMINANT LOADINGS													SELECTED TOTALS	
		CAPITAL (000$)	O&M (000$/YR)	ANNUALIZED (000$/YR)	TSS (KG/YR)	DOC (KG/YR)	OIL&GREASE (KG/YR)	AMMONIA + AMMONIUM (KG/YR)	SULPHIDE (KG/YR)	VSS (KG/YR)	PHENOLS (KG/YR)	CHROMIUM (KG/YR)	ZINC (KG/YR)	BENZENE (KG/YR)	TOLUENE (KG/YR)	m - & p - XYLENE (KG/YR)	o - XYLENE (KG/YR)	TSS, OIL &GREASE (KG/YR)	TOXICS (KG/YR)
ESSO (SARNIA) INITIAL (PRESENT) LOADINGS		→	→	→	125,743	100,985	11,403	4,417	308	108,792	33	0	177	17	25	30	22	137,146	304
OPTIONS:	TECHNOLOGIES:																		
CHEMICAL SUBST.		0	0	0	125,743	100,985	11,403	4,417	308	108;792	33	0	177	17	25	30	22	137,146	304
ONTARIO BPT FLOW	FRN, DAF, FND, EQN	26,789,490	4,368,960	5,454,165	125,743	100,985	11,403	4,417	308	108,792	33	0	177	8	8	17	19	137,146	262
NANTICOKE FLOW	FRN, DAF, FND, EQN	42,561,990	6,381,860	8,348,795	125,743	100,985	11,403	4,417	308	108,792	33	0	177	5	5	10	11	137,146	241
ESSO (NANTICOKE) INITIAL (PRESENT) LOADINGS		→	→	→	16,171	16,351	4,079	569	82	9,837	9	21	65	0	0	0	0	20,250	95
OPTIONS:	TECHNOLOGIES:																		
CHEMICAL SUBST.					16,171	16,351	4,079	569	82	9,837	9	21	65	0	0	0	0	20,250	95
NANTICOKE FLOW & AND CONCENTRATION		0	0	0	16,171	16,351	4,079	569	82	9,837	9	21	65	0	0	0	0	20,250	95
NOVA (CORUNNA) INITIAL (PRESENT) LOADINGS		→	→	→	35,135	33,784	3,859	1,308	472	19,025	12	524	934	0	0	0	0	38,994	1,470
OPTIONS:	TECHNOLOGIES:																		
CHEMICAL SUBST.	CAS	300,000	84,000	71,638	35,135	33,784	3,859	1,308	472	19,025	12	177	114	0	0	0	0	38,994	303
ONTARIO BPT FLOW	CAS, FLT, FND	3,085,855	402,651	569,279	35,135	33,784	3,859	1,308	356	19,025	12	177	114	0	0	0	0	38,994	303
NANTICOKE FLOW & AND CONCENTRATION	CAS, FRN, FLT, FND	7,023,355	910,151	1,391,904	29,551	23,441	3,859	1,308	197	19,025	12	98	63	0	0	0	0	33,410	173
PETRO-CANADA (MISSISSAUGA) INITIAL (PRESENT) LOADINGS		→	→	→	87,958	45,399	16,320	10,080	320	42,359	36	502	364	0	0	0	0	104,278	902
OPTIONS:	TECHNOLOGIES:																		
CHEMICAL SUBST.		300,000	53,000	53,038	87,958	45,399	16,320	10,080	320	42,359	36	235	150	0	0	0	0	104,278	421
ONTARIO BPT FLOW	DAF, FND	7,593,262	1,018,448	1,417,399	70,541	45,399	16,320	9,405	320	42,359	36	235	150	0	0	0	0	86,861	421
NANTICOKE FLOW & AND CONCENTRATION	FRN, DAF, FND	15,096,992	1,648,098	2,592,016	42,897	34,317	14,299	5,720	304	34,317	36	91	91	0	0	0	0	57,196	218
PETRO-CANADA (OAKVILLE) INITIAL (PRESENT) LOADINGS		→	→	→	36,422	30,092	3,576	7,814	286	24,675	71	158	2,539	2	1	3	7	39,998	2,779
OPTIONS:	TECHNOLOGIES:																		
CHEMICAL SUBST.	CAS	200,000	60,000	57,238	36,422	30,092	3,576	7,814	286	24,675	71	144	93	2	1	3	7	39,998	321
ONTARIO BPT FLOW	CAS	525,000	185,000	166,750	36,422	30,092	3,576	5,849	284	24,675	32	144	93	2	1	3	4	39,998	279
NANTICOKE FLOW & AND CONCENTRATION	CAS, FRN	2,038,125	380,025	444,445	22,692	18,153	3,576	3,026	151	18,153	17	74	49	1	1	3	2	26,268	147

able B.4 (cont.)

Final Contaminant Loadings By Refinery And BAT Option.

SOURCE TREATMENT PLAN		COSTS			FINAL CONTAMINANT LOADINGS													SELECTED TOTALS	
		CAPITAL (000$)	O&M (000$/YR)	ANNUALIZED (000$/YR)	TSS (KG/YR)	DOC (KG/YR)	OIL&GREASE (KG/YR)	AMMONIA + AMMONIUM (KG/YR)	SULPHIDE (KG/YR)	VSS (KG/YR)	PHENOLS (KG/YR)	CHROMIUM (KG/YR)	ZINC (KG/YR)	BENZENE (KG/YR)	TOLUENE (KG/YR)	m - & p - XYLENE (KG/YR)	o - XYLENE (KG/YR)	TSS, OIL &GREASE (KG/YR)	TOXICS (KG/YR)
SHELL (SARNIA) INITIAL (PRESENT) LOADINGS		→	→	→	241,503	77,748	14,918	1,458	97	145,922	29	142	167	7	6	6	3	256,421	360
OPTIONS: CHEMICAL SUBST.	TECHNOLOGIES: CAS	200,000	22,000	34,438	241,503	77,748	14,918	1,458	97	145,922	29	142	116	7	6	6	3	256,421	309
ONTARIO BPT FLOW	CAS, FEN, FLT, FMD	17,031,900	2,168,527	3,108,689	94,429	43,551	14,918	1,458	97	43,551	29	142	116	2	2	4	3	69,357	298
NANTICOKE FLOW & AND CONCENTRATION	CAS, FEN, FLT, FMD	20,475,730	2,613,677	3,742,534	35,312	28,250	11,771	1,458	97	28,250	26	74	74	1	1	3	3	47,083	182
SUNCOR (SARNIA) INITIAL (PRESENT) LOADINGS		→	→	→	22,709	23,958	3,418	4,535	66	14,592	20	65	170	2	2	2	2	26,127	261
OPTIONS: CHEMICAL SUBST.	TECHNOLOGIES: CAS	200,000	76,000	46,838	22,709	23,958	3,418	4,535	66	14,592	20	65	122	2	2	2	2	26,127	213
ONTARIO BPT FLOW	CAS, FLT, FMD	3,488,333	493,636	560,419	22,709	23,958	3,418	4,535	66	14,592	20	65	122	2	2	2	2	26,127	213
NANTICOKE FLOW & AND CONCENTRATION	CAS, FEN, FLT, FMD	9,159,583	1,353,486	1,784,752	22,709	23,958	3,418	4,352	66	14,592	20	65	70	1	1	1	1	26,127	199
TOTALS:	INITIAL (PRESENT) LOADINGS				565,642	328,317	57,572	30,180	1,630	365,202	209	1,414	4,416	27	33	40	34	623,213	6,172
	CHEMICAL SUBSTITUTION (CAS)	1,000,000	395,000	383,190	565,642	328,317	57,572	30,180	1,630	365,202	209	788	837	27	33	40	34	623,213	1,967
	ONTARIO BPT FLOW + CAS	57,503,900	8,617,222	11,276,701	344,989	277,770	53,493	26,973	1,433	252,994	162	766	772	13	12	25	27	398,482	1,777
	NANTICOKE FLOW + CAS	96,355,775	13,287,297	18,204,446	278,903	229,303	48,325	20,279	1,105	223,129	143	605	524	8	7	16	18	327,228	1,120

APPENDIX C

RESULTS FROM FINANCIAL ASSESSMENT

TABLE C-1

A COMPARISON OF THE IMPACT OF THE NANTICOKE FLOW + CAS BAT OPTION COST ESTIMATES ON THE PETROLEUM REFINING SECTOR'S (AGGREGATE*) HISTORICAL PERFORMANCE

Nanticoke Flow + CAS Option	Units of Financial Indicators	Worst Year (Lowest Operating Income) 1986 * FOUR FIRMS	TEN YEAR AVERAGE			1990		
Financial Indicators			Financial Indicators Before Regulatory Costs	Financial Indicators After Regulatory Costs	Change	Financial Indicators Before Regulatory Costs	Financial Indicators After Regulatory Costs	Change
Net Income	$'000s	568,000.0	784,204.5	768,719.5	-15,485.0	1,110,000.0	1,094,515.0	-15,485.0
Change in Net Income	%	00.0	00.0	-2.0	-2.0	00.0	-1.4	-1.4
Operating Income	$'000s	2,870,000.0	3,381,736.0	3,346,715	-35,021.0	3,846,000.0	3,810,979.0	-35,021.0
Internal Cash Flow	$'000s	2,215,000.0	2,372,644.8	2,366,372.0	-6,272.8	2,612,000	2,605,727.2	-6,272.8
Current Ratio	Times	2.0	1.8	1.8	0.0	1.4	1.4	0.0
Quick Ratio	Times	1.3	1.0	1.0	0.0	0.7	0.7	0.0
Interest Coverage	Times	10.1	11.9	11.5	-0.4	8.2	8.0	-0.2
Return on Capital Employed	%	4.4	5.3	5.2	-0.1	5.8	5.7	-0.1
Return on Assets	%	4.4	5.0	5.0	0.0	5.5	5.5	0.0
Return on Sales	%	3.1	4.0	3.9	-0.1	4.6	4.5	-0.1
EBIAT/Total Assets	%	3.7	4.5	4.5	0.0	5.5	5.5	-0.0
EBIT/Total Assets	%	12.5	15.6	15.5	-0.1	16.0	15.9	-0.1
Cash Flow to Debt	Times	19.1	18.7	18.5	-0.2	16.0	15.9	-0.1
Capital Expenditures	$'000s	2,178,000.0	3,010,819.1	3,028,183.1	17,364.0	2,054,000.0	2,071,364.0	17,364.0
MISA Capital Costs/Capital Expenditures	%	0.8	0.6	0.6	0.0	0.85	0.85	0.0
Operating Expenses	$'000s	15,331,000.0	16,297,157.0	16,297,157.0	0.0	20,460,000.0	20,460,000.0	0.00
MISA O&M Costs/ Operating Expenses	%	0.06	0.06	0.06	0.0	0.00	0.05	0.05
Total Debt to Total Assets	Times	48.0	50.8	51.1	0.3	52.7	52.9	0.2
Working Capital to Assets	Times	12.2	11.6	11.5	-0.1	6.3	6.3	0.0

TABLE C-2

A COMPARISON OF THE IMPACT OF THE ONTARIO BPT FLOW + CAS BAT OPTION COST ESTIMATES ON THE PETROLEUM REFINING SECTOR'S (AGGREGATE) HISTORICAL PERFORMANCE

ONTARIO BPT FLOW + CAS Option	Units of Financial Indicators	Worst Year (Lowest Operating Income) 1986	TEN YEAR AVERAGE			1990		
Financial Indicators			Financial Indicators Before Regulatory Costs	Financial Indicators After Regulatory Costs	Change	Financial Indicators Before Regulatory Costs	Financial Indicators After Regulatory Costs	Change
Net Income	$'000s	566,000.0	784,204.5	773,872.4	-10,332.1	1,110,000.0	1,099,667.9	-10,332.1
Change in Net Income	%	00.0	00.0	-1.3	-1.3	00.0	-09	-0.9
Operating Income	$'000s	2,670,000.0	3,381,736.0	3,358,601.8	-23,134.2	3,646,000.0	3,622,865.8	-23,134.2
Internal Cash Flow	$'000s	2,215,000.0	2,372,644.8	2,368,226.6	-4,418.2	2,612,000	2,607,581.8	-4,418.2
Current Ratio	Times	2.0	1.8	1.8	0.0	1.4	1.4	0.0
Quick Ratio	Times	1.3	1.0	1.0	0.0	0.7	0.7	0.0
Interest Coverage	Times	10.1	11.9	11.6	-0.3	8.2	8.1	-0.1
Return on Capital Employed	%	4.4	5.3	5.2	-0.1	5.8	5.7	-0.1
Return on Assets	%	4.4	5.0	5.0	0.0	5.5	5.5	0.0
Return on Sales	%	3.1	4.0	3.9	-0.1	4.6	4.6	0.0
EBIAT/Total Assets	%	3.7	4.5	4.5	0.0	5.5	5.5	0.0
EBIT/Total Assets	%	12.5	15.6	15.5	-0.1	16.0	16.0	0.0
Cash Flow to Debt	Times	19.1	18.7	18.6	-0.1	16.0	16.0	0.0
Capital Expenditures	$'000s	2,178,000.0	3,010,819.1	3,028,183.1	17,364.0	2,054,000.0	2,071,364.0	17,364.0
MISA Capital Costs/Capital Expenditures	%	0.0	0.0	0.5	0.5	0.00	0.70	0.70
Operating Expenses	$'000s	15,331,000.0	16,297,157.0	16,297,157.0	0.0	20,460,000.0	20,460,000.0	0.00
MISA O&M Costs/ Operating Expenses	%	0.03	0.03	0.03	0.03	0.040	0.04	0.00
Total Debt to Total Assets	Times	48.0	50.8	51.0	0.2	52.7	52.8	0.1
Working Capital to Assets	Times	12.2	11.6	11.5	-0.1	6.3	6.3	0.0

TABLE C-3

A COMPARISON OF THE IMPACT OF THE NANTICOKE FLOW + CAS BAT OPTION COST ESTIMATES ON ESSO CANADA'S FIRM-LEVEL HISTORICAL PERFORMANCE

NANTICOKE FLOW + CAS BAT OPTION	Units of Financial Indicators	Worst Year (Lowest Operating Income)	TEN YEAR AVERAGE			1990		
Financial Indicators		1986	Financial Indicators Before the Impact of Regulatory Costs	Financial Indicators After the Impact of Regulatory Costs	Change	Financial Indicators Before the Impact of Regulatory Costs	Financial Indicators After the Impact of Regulatory Costs	Change
Net Income	$'000s	285,000	463,900	456,102.9	-7,797.1	493,000	485,202.9	-7,797.1
Change in Net Income	%	00.0	00.0	-1.7	-1.7	00.0	-1.6	-1.6
Operating Income	$'000s	1,336,000	1,997,500	1,979,969	-17,531	2,130,000	2,112,469	-17,531
Internal Cash Flow	$'000s	851,000	992,300	989,038.9	-3,261.1	1,112,000	1,108,738.9	-3,261.1
Current Ratio	Times	2.7	2.1	2.1	0.0	1.3	1.3	0.0
Quick Ratio	Times	1.8	1.1	1.1	0.0	0.7	0.7	0.0
Interest Coverage	Times	14.8	14.1	13.6	-0.5	8.5	8.3	-0.2
Return on Capital Employed	%	6.5	6.9	6.8	-0.1	5.5	5.4	-0.1
Return on Assets	%	6.3	6.6	6.6	0.0	5.5	5.5	0.0
Return on Sales	%	4.1	5.5	5.4	-0.1	4.4	4.3	-0.1
EBIAT/TA	%	4.5	6.4	6.3	-0.1	5.5	5.5	0.0
EBIT/TA	%	16.0	23.2	23.0	-0.2	19.2	19.1	-0.1
Cash Flow to Debt	Times	23.9	21.5	21.2	-0.3	14.4	14.2	-0.2
Capital Expenditures	$'000s	848,000.0	1,512,400.0	1,520,003.0	7,603.00	668,000.0	675,603.0	7,603.0
MISA Capital Costs/Capital Expenditures	%	1.17	0.50	0.50	0.50	1.14	1.14	1.14
Operating Expenses	$'000s	5,828,000.0	6,519,800.0	6,519,800.0	0.0	9,096,000.0	9,096,000.0	0.0
MISA O&M Costs/Operating Expenses	%	0.013	0.011	0.011	0.011	0.008	0.008	0.008
Total Debt to Total Assets	Times	41.1	46.5	46.8	0.3	51.0	51.1	0.1
Working Capital to Assets	Times	17.5	14.1	13.9	-0.2	4.5	4.4	-0.1

TABLE C-4

A COMPARISON OF THE IMPACT OF THE BEST AVAILABLE TECHNOLOGY (BAT) OPTION COST ESTIMATES ON PETRO CANADA'S FIRM-LEVEL HISTORICAL PERFORMANCE

NANTICOKE FLOW + CAS BAT OPTION	Units of Financial Indicators	Worst Year: 1988	TEN YEAR AVERAGE			1990		
Financial Indicators			Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change	Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change
Net Income	$'000s	-33,000.0	58,554.5	55,760.5	-2,794.0	181,000.0	178,206.0	-2,794.0
Change in Net Income	%	00.0	00.0	-4.8	-4.8	00.0	-1.5	-1.5
Operating Income	$'000s	281,000	610,586	604,241	-6,345.0	583,000.0	576,655	-6,345.0
Internal Cash Flow	$'000s	514,000.0	673,004.8	671,899.7	-1,105.1	590,000.0	588,894.9	-1,105.1
Current Ratio	Times	0.8	1.3	1.3	0.0	1.0	1.0	0.0
Quick Ratio	Times	0.5	0.7	0.7	0.0	0.5	0.5	0.0
Interest Coverage	Times	6.8	13.9	13.3	-0.6	6.7	6.5	-0.1
Return on Capital Employed	%	0.6	2.9	2.8	0.0	4.9	4.8	0.0
Return on Assets	%	0.9	2.7	2.7	0.0	4.4	4.3	0.0
Return on Sales	%	-0.7	1.3	1.2	0.1	3.2	3.1	0.0
EBIAT/TA	%	0.6	1.5	1.5	0.0	4.4	4.3	0.0
EBIT/TA	%	6.8	8.7	8.6	-0.1	12.5	12.5	0.0
Cash Flow to Debt	Times	12.8	15.1	15.0	-0.1	12.8	12.7	-0.1
Capital Expenditures	$'000s	869,000.0	665,300.0	668,359.0	3,059.0	643,000.0	646,059.0	3,059.0
MISA Capital Costs/Capital Expenditures	%	0.35	0.48	0.48	0.48	0.48	0.48	0.48
Operating Expense	$'000s	4,388,000.0	3,944,697.0	3,944,697.0	0.0	5,097,000.0	5,097,000.0	0.0
MISA O&M Costs/Operating Expenses	%	0.063	0.070	0.070	0.0	0.054	0.054	0.0
Total Debt to Total Assets	Times	59.6	57.5	57.6	0.1	63.3	63.4	0.1
Working Capital to Assets	Times	-4.2	5.4	5.3	-0.1	-0.8	-0.9	0.0

TABLE C-5

A COMPARISON OF THE IMPACT OF THE NANTICOKE FLOW BAT OPTION COST ESTIMATES ON SHELL'S FIRM-LEVEL HISTORICAL PERFORMANCE

NANTICOKE FLOW + CAS BAT OPTION	Units of Financial Indicators	Worst Year: 1989	TEN YEAR AVERAGE			1990		
Financial Indicators			Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change	Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change
Net Income	$'000s	212,000.0	214,700.0	211,424.8	-3,275.2	312,000.0	308,724.8	-3,275.2
Change in Net Income	%	00.0	00.0	-1.5	-1.5	00.0	-1.1	-1.1
Operating Income	$'000s	288,000.0	449,500.0	441,492.0	-7,509.0	430,000.0	422,491.0	-7,509.0
Internal Cash Flow	$'000s	510,000.0	521,400.0	520,174.7	-1,225.3	626,000.0	624,774.7	-1,225.3
Current Ratio	Times	2.7	2.3	2.2	0.0	2.5	2.5	0.0
Quick Ratio	Times	1.6	1.2	1.2	0.0	1.2	1.2	0.0
Interest Coverage	Times	5.8	6.0	5.8	-0.2	6.4	6.2	-0.2
Return on Capital Employed	%	5.1	6.2	6.1	-0.1	6.9	6.8	-0.1
Return on Assets	%	5.1	6.0	6.0	0.0	6.5	6.5	0.0
Return on Sales	%	4.4	4.1	4.1	0.0	5.7	5.7	0.0
EBIAT/TA	%	5.1	5.9	5.9	0.0	6.6	6.5	0.0
EBIT/TA	%	7.7	11.1	10.9	-0.2	9.5	9.4	-0.1
Cash Flow to Debt	Times	19.7	19.3	19.1	-0.2	21.8	21.6	-0.2
Capital Expenditures	$'000s	713,000.0	613,100.0	616,763.0	3,663	575,000.0	578,863.0	3,863.0
MISA Capital Cost/Capital Expenditures	%	0.51	0.60	0.60	0.60	0.64	0.64	0.64
Operating Expenses	$'000s	4,556,000.0	4,738,200.0	4,738,200.0	0.0	5,014,000.0	5,014,000.0	0.0
MISA O&M Costs/Operating Expenses	%	0.066	0.064	0.064	0.0	0.060	0.060	0.0
Total Debt to Total Assets	Times	45.7	50.5	50.8	0.3	46.6	46.9	0.2
Working Capital to Assets	Times	18.1	18.5	18.4	-0.1	19.3	19.2	-0.1

TABLE C-6

A COMPARISON OF THE IMPACT OF THE NANTICOKE FLOW BAT OPTION COST ESTIMATES ON SUNCOR'S FIRM-LEVEL HISTORICAL PERFORMANCE

NANTICOKE FLOW + CAS BAT OPTION	Units of Financial Indicators	Worst Year: 1986	TEN YEAR AVERAGE			1990		
Financial Indicators			Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change	Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change
Net Income	$'000s	-7,000.0	48,950.0	47,331.2	-1,618.8	124,000.0	122,381.2	-1,618.8
Change in Net Income	%	00.0	00.0	-3.3	-3.0	00.0	-1.30	-1.30
Operating Income	$'000s	158,000.0	349,850.0	346,214.0	-3,636.0	503,000.0	499,364.0	-3,636.0
Internal Cash Flow	$'000s	150,000.0	203,440.0	202,758.7	-681.3	284,000.0	283,318.7	-681.3
Current Ratio	Times	1.3	1.3	1.3	0.0	1.5	1.4	0.0
Quick Ratio	Times	0.7	0.7	0.7	0.0	0.9	0.9	0.0
Interest Coverage	Times	5.7	17.5	16.6	-0.9	19.7	18.9	-0.8
Return on Capital Employed	%	1.2	4.1	4.0	-0.1	7.2	7.2	0.0
Return on Assets	%	1.7	3.9	3.8	0.0	6.7	6.6	-0.1
Return on Sales	%	-0.8	3.4	3.3	-0.1	7.1	7.0	-0.1
EBIAT/TA	%	1.3	3.3	3.3	0.0	6.7	6.6	0.0
EBIT/TA	%	9.0	17.5	17.3	-0.2	23.6	23.4	-0.2
Cash Flow to Debt	Times	14.3	20.5	20.2	-0.3	27.0	26.7	-0.3
Capital Expenditures	$'000s	119,000.0	218,890.0	220,584.0	1,694.0	168,000.0	169,694.0	1,694.0
MISA Capital Costs/Capital Expenditures	%	1.42	0.77	0.77	0.77	1.01	1.01	1.01
Operating Expenses	$'000s	994,000	1,094,460.0	1,094,460.0	0.0	1,253,000.0	1,253,000.0	0.0
MISA O&M Costs/Operating Expenses	%	0.166	0.151	0.151	0.0	0.132	0.132	0.0
Total Debt to Total Assets	Times	49.7	47.1	47.4	0.3	46.6	46.9	0.3
Working Capital to Assets	Times	3.5	4.7	4.6	-0.1	6.5	6.4	-0.1

TABLE C-7

A COMPARISON OF THE IMPACT OF THE NANTICOKE FLOW BAT OPTION COST ESTIMATES ON SUNCOR'S SEGMENTED (DIVISIONAL) HISTORICAL PERFORMANCE

NANTICOKE FLOW + CAS BAT OPTION			TEN YEAR AVERAGE			1990		
Financial Indicators	Units of Financial Indicators	Worst Year: 1981	Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change	Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change
Operating Income	$'000s	18,000.0	31,700.0	28,064.4	-3,635.6	56,000.0	52,364.4	-3,635.6
Net Income	$'000s	53,000.0	24,100.0	27,125.2	3,025.2	51,000.0	54,025.2	3,025.2
Change in Net Income	%	0.0	0.0	12.6	12.6	0.0	5.9	5.9
Return on Sales	%	4.8	1.9	2.2	0.2	3.3	3.5	0.2
Return on Assets	%	8.7	3.1	3.4	0.4	5.2	5.5	0.3
Total Assets to Sales	%	53.3	62.8	63.5	0.7	63.3	63.8	0.5
Expenses to Sales	%	98.4	97.4	97.7	0.3	98.4	98.6	0.2
Operating Expenses	$'000s	1,127,000.0	1,201,700.0	1,201,700	0.0	1,271,000.0	1,271,000.0	0.0
MISA O&M Costs/Operating Expenses	%	0.148	0.137	0.137	0.0	0.130	0.130	0.0
Capital Expenditures	$'000s	38,000.0	62,800.0	62,800.0	0.0	51,000.0	51,000.0	0.0
Ann. MISA Capital Costs/ Capital Expenditures	%	4.3	2.7	2.7	0.0	3.3	3.3	0.0

TABLE C-8

A COMPARISON OF THE IMPACT OF THE NANTICOKE FLOW BAT OPTION COST ESTIMATES ON ESSO CANADA'S SEGMENTED (DIVISIONAL) HISTORICAL PERFORMANCE

NANTICOKE FLOW + CAS BAT OPTION			TEN YEAR AVERAGE			1990		
Financial Indicators	Units of Financial Indicators	Worst Year: 1990	Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change	Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change
Operating Income	$'000s	666,000.0	1,461,600.0	1,444,068.9	-17,531.1	666,000.0	648,468.9	-17,531.1
Net Income	$'000s	222,000.0	182,700.0	197,301.0	14,601.0	222,000.0	236,601.0	14,601.0
Change in Net Income	%	0.0	0.0	8.0	8.0	0.0	6.6	6.6
Return on Sales	%	3.6	5.0	5.3	0.3	3.6	3.8	0.2
Return on Assets	%	2.3	2.6	2.8	0.2	2.3	2.4	0.1
Total Assets to Sales	%	63.5	52.1	52.7	0.6	63.5	63.9	0.4
Expenses to Sales	%	93.2	78.3	78.5	0.2	93.2	93.4	0.2
Operating Expenses	$'000s	8,881,000.0	5,844,617.0	5,844,617.0	0.0	8,881,000.0	8,881,000.0	0.0
MISA O&M Costs/Operating Expenses	%	0.008	0.013	0.013	0.0	0.008	0.008	0.0
Capital Expenditures	$'000s	192,000.0	192,000.0	387,400.0	387,400.0	192,000.0	192,000.0	0.0
Ann. MISA Capital Costs/ Capital Expenditures	%	4.0	4.0	2.0	2.0	4.0	4.0	0.0

TABLE C-9

A COMPARISON OF THE IMPACT OF THE NANTICOKE FLOW BAT OPTION COST ESTIMATES ON PETRO CANADA'S SEGMENTED HISTORICAL PERFORMANCE

NANTICOKE FLOW + CAS BAT OPTION			TEN YEAR AVERAGE			1990		
Financial Indicators	Units of Financial Indicators	Worst Year: 1989	Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change	Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change
Operating Income	$'000s	-131,000.0	226,800.0	220,454.5	-6,345.5	-125,000.0	-131,345.5	-6,345.5
Net Income	$'000s	104,000.0	229,100.0	234,427.3	5,327.3	126,000.0	131,327.3	5,327.3
Change in Net Income	%	0.0	0.0	2.3	2.3	0.0	4.2	4.2
Return on Sales	%	2.3	6.1	6.3	0.1	2.5	2.7	0.1
Return on Assets	%	3.1	7.9	8.1	0.1	3.4	3.5	0.1
Total Assets to Sales	%	76.7	77.3	77.7	0.4	74.7	75.0	0.3
Expenses to Sales	%	102.9	93.9	94.1	0.2	102.5	102.7	0.1
Operating Expenses	$'000s	4,338,000.0	3,460,100.0	3,460,100.0	0.0	4,712,000.0	4,712,000.0	0.0
MISA O&M Costs/Operating Expenses	%	0.063	0.079	0.079	0.0	0.058	0.058	0.0
Capital Expenditures	$'000s	210,000.0	210,000.0	152,700.0	0.0	232,000.0	232,000.0	0.0
Ann. MISA Capital Costs/ Capital Expenditures	%	1.5	1.5	2.0	0.0	1.3	1.3	0.0

TABLE C-10

A COMPARISON OF THE IMPACT OF THE NANTICOKE FLOW BAT OPTION COST ESTIMATES ON SHELL'S SEGMENTED (DIVISIONAL) HISTORICAL PERFORMANCE

NANTICOKE FLOW + CAS BAT OPTION			TEN YEAR AVERAGE			1990		
Financial Indicators	Units of Financial Indicators	Worst Year: 1983	Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change	Financial Ratios Before the Impact of Abatement Costs	Financial Ratios After the Impact of Abatement Costs	Change
Operating Income	$'000s	57,000.0	204,400.0	196,891.6	-7,508.4	338,000.0	330,491.6	-7,508.4
Net Income	$'000s	23,000.0	93,700.0	100,049.9	6,349.9	154,000.0	160,349.9	6,349.9
Change in Net Income	%	0.0	0.0	6.8	6.8	0.0	4.1	4.1
Return on Sales	%	0.6	2.5	2.6	0.2	3.7	3.9	0.2
Return on Assets	%	1.0	4.2	4.4	0.2	5.6	5.8	0.2
Total Assets to Sales	%	57.6	59.5	60.0	0.5	66.7	67.1	0.4
Expenses to Sales	%	98.5	94.6	94.8	0.2	91.8	92.0	0.2
Operating Expenses	$'000s	3,812,000.0	3,302,022.0	3,302,022.0	0.0	3,863,000.0	3,863,000.0	0.0
MISA O&M Costs/Operating Expenses	%	0.079	0.091	0.091	0.0	0.078	0.078	0.0
Capital Expenditures	$'000s	273,000.0	149,800.0	149,800.0	0.0	148,000.0	148,000.0	0.0
Ann. MISA Capital Costs/ Capital Expenditures	%	1.3	2.4	2.4	0.0	2.5	2.5	0.0

APPENDIX D

DEFINITION AND CALCULATION OF STANDARD RATIOS

DEFINITION AND CALCULATION OF FINANCIAL INDICATORS

I. CORPORATE/FIRM/SECTOR LEVEL INDICATORS

Liquidity Indicators

Quick Ratio (x:1)	(Current assets [less inventories] / Current liabilities) Quick ratio indicates the level of protection provided to short term creditors. It shows the number of dollars of liquid assets (i.e., assets that are easily convertible to cash such as marketable securities, term deposits) available to cover each dollar of current debt. A quick ratio of 1:1 or greater indicates that the business is in a liquid position.
Note:	Current assets include cash and other assets that will either be transformed into cash or will be sold or consumed within one year or within the normal operating cycle of the business, if longer than one year.
Current Ratio (x:1)	(Current assets / Current liabilities) Current ratio indicates the degree to which a company has sufficient current assets to cover current liabilities. The higher the ratio the greater the assurance that current liabilities can be met. A current ratio of 2:1 or better is generally considered desirable.
Net Working Capital to Total Assets (%)	{(Current assets - Current liabilities) / Total assets} x 100 Net working capital to total assets ratio indicates the proportion of total company assets which are currently available to cover unexpected expenses.

Solvency Indicators

Total Debt to Total Assets (%)	{(Total debt / Total assets) x 100} Total debt to total assets measures the degree to which a

company is leveraged (i.e., financed by outside debt). A higher total debt/total assets ratio indicates that the company is highly leveraged which may limit their ability to raise additional capital (at a reasonable interest rate) to finance large capital expenditures.

Interest Coverage (Times)	{(Net income before interest, extraordinary items and all taxes) / Annual interest charges} Interest coverage provides information on the extent to which a company's normal operating income is sufficient to cover annual interest charges. A company with a low interest coverage ratio may be unable to pay its annual interest charges and would therefore have a higher risk of being forced into insolvency by creditors.
Cash Flow ($)	Net income before extraordinary items and all non-cash expenses (e.g., depreciation, amortization, deferred taxes) Cash flow provides a measure of a company's ability to pay dividends and finance expansion. A company which shows little net after-tax profit may still be able to meet its short term debts and obligations if cash flow is adequate.
Cash Flow to Total Debt (Beaver's Ratio) (%)	{[(Net income before extraordinary items, depreciation and deferred taxes) / Total debt] x 100} Cash flow to total debt indicates the percentage of total debt which is covered by current cash flow. This should be considered in relation to the number of years the debt is being amortized.

Profitability Indicators

Return on Assets (%)	{[Net income (before interest and extraordinary items but after taxes)/Total assets] x 100} Return on assets is a key indicator of a company's profitability. It matches net after-tax profits (from normal operations) with the assets available to earn a return. Companies that are using their assets efficiently will have a relatively high rate of return. Excluding interest from the definition of normal operating income

eliminates any bias resulting from a company's decision to finance assets through long term debt versus raising additional capital internally (i.e, through issuing shares).

Return on Net Assets (RONA) (%)	{[Net income (before interest and extraordinary items but after taxes) / (Total assets - Total liabilities)] x 100} Similar to return on assets except the return is expressed as a percentage of net assets.
Earnings Before Interest but After Taxes to Total Assets (EBIAT/TA) (%)	{(Net income before interest but after taxes / Total assets) x 100} Similar to return on assets (above) except the definition of net income includes extraordinary items.
Earnings Before Interest and Taxes to Total Assets (EBIT/TA) (%)	(Net income before interest and all taxes / Total assets) x 100 Similar to return on assets (above) except the net income is before taxes and includes extraordinary items.
Return on Sales (Profit Margin) (%)	{Net income (after taxes)/ Sales} x 100 Return on sales measures the profits earned per dollar of sales indicating the profitability of the company. It also indicates the company's ability to survive adverse conditions such as falling prices, rising costs and declining sales.
Return on Capital Employed %	{Net income (after taxes) plus after tax interest charges and extraordinary items / Total assets less current liabilities} x 100 This measures the rate of return being earned on company assets

employed in operations. It provides an indication of the level of incentive for owners and investors to remain in that particular enterprise.

Net Income (Profit) ($)	Total revenue less all expenses (cost of sales, operating expenses, taxes)

Efficiency Indicators

Total Assets Sales (%)	(Total Assets/Sales) x 100 Total assets to sales indicates the level of investment that is required to generate those sales. A high percentage (in comparison to industry averages) may indicate that the company is not using assets efficiently or needs to market its product more aggressively.

Other Indicators

Amortized and Total Regulatory Capital Costs as a Percent Recorded Capital Expenditures (%)	(Amortized or Total Regulatory Capital Cost / Total Recorded Capital Expenditures) x 100 This ratio indicates the extent to which capital requirements implied by regulatory requirements would divert available capital resources from other uses.
Regulatory Operating Expenses as a Percent of Recorded Operating Expenditures (%)	(Regulatory-induced Annual Operating Expenses / Recorded operating and maintenance expenses) x 100 This ratio indicates the extent to which operating and maintenance expenses would increase due regulatory-induced operating costs.

II. DIVISION/PLANT LEVEL INDICATORS

Profitability Indicators

Operating profits	Total revenue less operating expenses ($) (includes cost of sales)
Return on Assets (%)	(Operating profits / Assets) x 100 Key indicator to assess divisional profitability. It also provides a rough assessment of the return on investment at the level of the division.
Return on Sales (%)	(Operating profits / Sales) x 100 Assesses a division's capacity to withstand unfavourable market conditions such as falling product prices, rising input costs or depressed sales volumes.
Return per Unit of production ($/unit)	(Operating profits / Sales volume or units) This ratio measures the contribution of each unit of sale to profits. In conjunction with the expenses index, it provides a composite assessment of a division's efficiency in converting raw materials to consumable products.

Efficiency

Expenses to Sales (%)	(Expenses / Sales) x 100 This ratio shows the proportion of sales revenue that goes towards the recovery of production costs. The lower this ratio the higher the division's profits.
Cost per Unit ($/unit)	{Expenses / Sales volume} (quantity) Indicates the unit cost of manufacturing the product.

APPENDIX E

PROCEDURE FOR ADJUSTING FINANCIAL DATA

PROCEDURE FOR ADJUSTING FINANCIAL DATA

Debt Financing Option

Key Figures Impacted		Amounts for Impact
Balance Sheet		
-Fixed Assets	**Add:**	Capital cost of abatement (& monitoring) less 1st year depreciation.
-Other Current Assets	**Deduct:**	Current years payment on long-term debt (LTD)
-Current portion of LT Debt	**Add:**	Current portion of LTD, principal payable within the next year.*
-Long term Debt	**Add:**	Year end balance of LTD related to abatement costs (Initial capital cost less 1st year (amortized) payment and current portion for following year).*
-Share Capital	**Add:**	N/A
-Retained Earnings	**Add:**	After abatement net income (less pre-abatement net income)
Income Statement		
-Depreciation	**Add:**	1 year of depreciation of capital costs.
-Interest	**Add:**	1st year interest on LTD.*
-Operating Expenses	**Add:**	Annual O&M (monitoring and abatement) costs.
-Current income	**Deduct:**	Tax impact of higher interest, O&M and capital costs (use capital cost allowance (CCA) rate of 25 or 35.9%).
-Net Income		Previous net income adjusted for impact of above changes.
Other		
-Capital exp.	**Add:**	Capital exp. for abatement and monitoring

* Appropriate amounts can be determined from completing the 1st two years of a loan amortization schedule.

** Interest expense determined as an internal cost of capital

APPENDIX F

CALCULATION OF CAPITAL COST RECOVERY AND NET PRESENT VALUE OF TAX SAVINGS

CALCULATION OF CAPITAL COST RECOVERY AND NET PRESENT VALUE OF TAX SAVINGS

1. **SIMPLE CASE:**

Interest Rate (i) = 12%, Useful Life (n) = 10 years,
Income Tax rate (T) = 40%,
Capital Recovery Factor (cf) = 0.113

2. **DETERMINING TAX SAVINGS:**

i = 12%, n = 10 years, income tax (T) = 40%,

Capital Cost Allowance (CCA) rate = 25/50/25%

Tax savings claimable = (investment x CCA rate x income tax rate)

The following worked example is base on $1 investment made in year 1:

		Year 1	**Year 2**	**Year 3**
Investment	$1			
CCA rate applicable	0.25%	O.50%	0.25%	
Tax Savings	$0.10	$0.20 ($1*0.25*0.40)	$0.10	
NPV factors	1.000	0.8290	0.7972	

Present Value of Tax Savings:

Year 1 = 0.1000 (0.1*1.0000)
Year 2 = 0.1790 (0.2*0.8290)
Year 3 = 0.0800 (0.1*0.7972)
TOTAL = 0.3590

After Tax Investment = 0.6410 (1-0.3590)

For every $1 invested in environmental control $0.359 is recouped in tax savings. Therefore, the effective capital outlay is $0.641 (i.e., $1 - $0.359).

3. **CAPITAL RECOVERY:**

After Tax Capital Recovery = 0.113

Before Tax Recovery = 0.188 (0.113/0.6)